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Department of Applied Mathematics Academic Program Review, Self Study / June 2010

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Department of Applied Mathematics

Academic Program Review

Self Study

Carlos F. Borges
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INTRODUCTION

The Department of Applied Mathematics has a multi-faceted mission to provide an exceptional mathematical education focused on the unique needs of NPS students, to conduct relevant research, and to provide service to the broader community. A strong and vibrant Department of Applied Mathematics is essential to the university's goal of becoming a premiere research university. Because research in mathematics often impacts science and engineering in surprising ways, the department encourages mathematical explorations in a broad range of areas in applied mathematics with specific thrust areas that support the mission of the school.

The Department of Applied Mathematics has not undergone an external academic program review since June, 1985 (the documentation for this review can be found in the appendices) and has not undergone a curriculum review since the cancellation of the Applied Mathematics (380) curriculum in early 2001. This year, the Department will undergo the first external program review of its teaching, research, and service programs in 25 years. The goal of this review is to assess where we stand with regard to our academic programs and to provide recommendations on how we can further improve our programs. This Review Document is intended to provide the Review Committee, as well as the department's faculty, staff, and students, the background material needed to help assess our progress.

THE ROLE OF THE NAVAL POSTGRADUATE SCHOOL

The Naval Postgraduate School exists for the sole purpose of increasing the combat effectiveness of the Navy and Marine Corps. Although the school is legally established by Title 10 U.S. Code, Subtitle C, Chapter 605, Sections 7041-7047, the policies concerning the school and its charter are laid out very succinctly in SECNAVINST 1524.2B. The latter document is very important as it outlines the kinds of programs the school is to provide, the nature of the faculty, and the relationship between the school and the wider Navy.

In recent years, the school has also developed a rather general strategic plan that delineates the future directions of the school and its relation to the Navy and to the broader national security needs of the United States. What follows in this section is quoted from that document:

> *"Introduction*
>
> *The Naval Postgraduate School (NPS) is a unique graduate school — an institution dedicated to providing education and research with a focus on relevance to the defense and security arenas and on recognizing and innovatively solving problems in support of our military forces, our country's global partners and our national security. While there are many civilian universities that provide graduate education, there are few that are dedicated to providing national security-related graduate educational programs for military officers, as well as federal, state and local government civilian employees and contractors. The Naval Postgraduate School is such a place.*
>
> *Mission Statement*
>
> *NPS provides high-quality, relevant and unique advanced education and research programs that increase the combat effectiveness of the Naval Services, other Armed Forces of the U.S. and our partners, to enhance our national security.*
>
> *Background*
>
> *At NPS, four world-class Schools oversee fourteen academic departments that provide more than 42 master's and 18 doctoral degree programs and certificates to 1,800 resident students, including 300 international students, as well as approximately 900 distributed-learning students worldwide. Four Institutes, multiple secure research facilities and twenty-three Centers of Excellence add to the wealth of resources. Non-resident courses are delivered to students through online, web-enabled, video-tele-education systems and/or by visiting faculty. Continuous learning, refresher and transitional educational opportunities abound, and short-term executive education courses and a variety of short courses are also offered by NPS, both in Monterey and abroad.*
>
> *Approximately 500 scholars and professionals, 10 percent of whom are military officers and half of whom are tenured or tenure-track, comprise the NPS faculty. To strengthen expertise and program relevance, and to expedite research successes at NPS, a robust mix of tenured faculty, lecturers and visiting professionals integrate teaching with research, demonstrating*

the immediate applicability of defense-related theories to defense-related solutions, many times resulting in patent-eligible technologies.

The NPS Board of Advisors functions as an eighteen-member federal advisory committee that provides guidance to NPS, and reports to the Secretary of the Navy, the Chief of Naval Operations and the Commandant of the Marine Corps on matters pertaining to the School and its graduate education and research programs.

Well-positioned to continue to develop as the nation's premier educational and research institution for defense and national security, Vision for a New Century details the School's strategic drivers and goals through 2012, and is designed to guide the university in making the critical choices necessary to maintain and enhance its leadership position"

PEER COMPARISON STUDY

In 2008 NPS commissioned a peer comparison study from CES Consultants to evaluate the overall institution against a carefully selected group of peer institutions. The intent of the peer analysis was to provide quantitative information on the range and magnitude of a number of key performance indicators to help NPS identify strengths and weaknesses, and specific areas for improvement. Fifteen specific peer institutions (CES peers) were selected for comparison:

California Institute of Technology
Carnegie Mellon University
Claremont Graduate University
Duke University
Georgia Institute of Technology
Illinois Institute of Technology
Massachusetts Institute of Technology
North Carolina State University
Rensselaer Polytechnic Institute
Rice University
Stanford University
Stevens Institute of Technology
University of California, Santa Barbara
University of Illinois, Urbana-Champaign
University of Southern California

A wide variety of specific data was collected for all of the institutions, and then averages and rankings in various categories were computed. The final report was issued in January 2009, and we shall refer to the results of the CES peer comparison in various parts of this self-study for purposes of assessment.

In 2010, NPS commissioned another study from Academic Analytics, LLC. The purpose of this study, which we shall refer to as AA2010, was to generate quantitative measures of faculty scholarly productivity at NPS.

OVERVIEW OF THE DEPARTMENT OF APPLIED MATHEMATICS

THE MISSION OF THE DEPARTMENT

The mission of the Department of Applied Mathematics is to provide an exceptional mathematical education focused on the unique needs of our students, to engage in relevant research, and to provide quality service to the community. We are deeply committed to maintenance of a well-designed curriculum and a supportive environment for our students.

Because mathematics is the language of science, it is fundamental to every quantitative science and technology curriculum on campus. The primary role of the department is one of service to the various technical curricula at NPS. This includes a very high proportion of remedial undergraduate level coursework that is necessary for students who are transitioning to graduate study after a long period away from university. The Department of Applied Mathematics strives to provide a solid mathematical foundation for all students as they make the transition into graduate curricula. We provide high-quality instruction in all courses, giving emphasis to relevant and modern mathematical techniques in our advanced courses. And we encourage students to develop and utilize skills in analysis, reasoning, creativity, and exposition as they acquire knowledge of mathematics and its applications. We regularly engage with our client curricula to ensure that our service courses remain up to date and meet their needs.

There are also a very small number of students who are seeking degrees in Applied Mathematics. The primary sponsor for students seeking a degree in Applied Mathematics is the Department of Mathematics at the United States Military Academy (USMA). These students come here for graduate study as preparation for an assignment to teach mathematics at USMA. Prior to the cancellation of the 380 curriculum in early 2001, we also had a contingent of Naval officers who were preparing to teach mathematics at the United States Naval Academy (USNA) as well as one or two Marine Corps officers (to be similarly detailed). We also support a number of students who decide to pursue a dual degree program while at NPS. We have found this to be an excellent way to enhance our interdisciplinary activities across the campus.

In addition, we maintain active research programs, making a special effort to respond to the needs of the NPS, DoN and DoD communities. By adhering to the most stringent standards of scholarship, we ensure that the department continues to hold the respect of the community of scholars worldwide. We serve our profession, not only through scholarship, but also by our involvement in professional organizations and by our editorial and administrative contributions to the growing body of mathematical knowledge. We also serve the NPS community with our active role in the governance of the School.

HISTORY OF MATHEMATICS AT NPS

The Department of Applied Mathematics has the longest history of any department at the Naval Postgraduate School and traces its origins to the appointment of Ensign Guy K. Calhoun as Professor of Mathematics in 1910. He would later become the first faculty member assigned to the Postgraduate Department that was created at Annapolis in 1912 to function as a preparatory school whose students would complete their graduate studies at a civilian institution after a year of study at Annapolis. The department was headed by a single officer with a small office staff and the assistance of a single civilian engineer. At its inception, the department had no regular faculty but relied on the cooperation of civilian institutions as well as regular faculty from the academic departments at USNA. Prof. Ralph E. Root, who had originally joined the faculty in the Mathematics Department at Annapolis in 1913, quickly became involved in the fledgling Postgraduate Department, and in 1914 he became the first civilian faculty member of the new department when he was appointed as its Professor of Mathematics and Mechanics. He had earned his Ph.D. at the University of Chicago in 1911 under the direction of the illustrious Prof. E.H. Moore whose list of doctoral students includes such notables as George Birkhoff, Leonard Dickson, Theophil Hildebrandt, R.L. Moore, and Oswald Veblen. Indeed, Root's dissertation work was so fundamental to the early development of the concept of 'neighborhood' that it encompasses an entire section in Aull and Lowen's Handbook of the History of General Topology.

By 1931 the Postgraduate Department had evolved into a Postgraduate School that had fifteen faculty – four in Mathematics and Mechanics (C.C. Bramble, W.R. Church, C.H. Rawlins, and R.E. Root), three in Mechanical Engineering, three in Electrical Engineering, two in Metallurgy and Chemistry, one in Physics, one in Radio, and one in Modern Languages.

In 1946 Captain Herman A. Spanagel (appointed Head of the Postgraduate School in April, 1944) instituted a major reorganization of the school that created, for the first time, traditional academic departments. The Department of Mathematics and Mechanics was one of the seven original academic departments created in this reorganization, and Prof. W.R. Church was appointed as chairman. Professor Church, who had spent the war years on active duty in the Navy, was a keen student of new developments in applied mathematics. The applications of statistics to strategy in anti-submarine warfare had led to many other applications in the analysis of naval operations. As this new area of science continued to grow after the end of the war, Professor Church and the Department of Mathematics and Mechanics were leaders in the development of the new curriculum in operations analysis, which began in 1951-52. Professors Torrance from Mathematics and Cunningham from Physics taught the initial courses in this discipline. They were soon assisted by Professor Tom Oberbeck, who joined the Mathematics faculty in 1951. After a period of growth and development, during which several statisticians were added to the faculty to handle the gradual shift in emphasis from physical science to statistical analysis as the curriculum adjusted to the needs of the Navy, the School created the Department of Operations Research with Oberbeck as Chairman in 1962. He was succeeded, three years later, by Jack Borsting, who was also from the Department of Mathematics and Mechanics.

In 1966, the separation of Operations Research from Mathematics was completed with the transfer of statistics to the Department of Operations Research along with five of the professors who covered this subject. At this time the offspring to which Mathematics had given birth had nineteen professors and was still growing. This is the same year that the Department of Mathematics and Mechanics changed its name to the Department of Mathematics and R.E. Gaskell took over as chairman following twenty years of impeccable leadership by W.R. Church.

Professor Church was also keenly interested in the development of the computer world, started in the war years by the Harvard Mark I and by the University of Pennsylvania Moore School Computer. Indeed, the Department of Mathematics and Mechanics had already played a pivotal role in the history of computing by that point, as it was our own Prof. C.C. Bramble who had recommended the development of the Harvard Mark II for the Naval Proving Ground at Dahlgren. Howard Aiken, computer pioneer and developer of the Mark II, recalls it this way in an interview in February, 1973:

> *“Mark II was built for the Naval Proving Ground at Dahlgren on the recommendation of Professor Clinton Bramble of the United States Naval Academy, who was a mathematician and who was on duty as a Naval Officer. And Bramble was able to foresee that they had to quit this hand stuff in the making of range tables. That's why we built the computer. And Albert Worthheimer found the money for it and signed the contract.*
>
> *In November of 1944, the Bureau of Ordnance requested the Computation Laboratory, then operating as a naval activity, undertake the design and construction of an automatic digital calculator for installation at the Naval Proving Ground."*

It is interesting to note the Prof. Bramble’s first contacts with Dahlgren were in 1924. He notes in a January 1977 interview that:

> *“In those days, there was no bridge across the Potomac. I used to call up, and they'd send a boat over to Morgantown, Maryland, for me. When I came down, it was just for general interest in ordnance problems while I was teaching ordnance courses at the Naval Postgraduate School. The courses included ballistics and gun design, both exterior and interior ballistics.*
>
> *Naturally I was interested in the current problems in those areas, so periodically I would get in touch with Dr. Thompson, who was at that time the Senior Scientist at Dahlgren. It was a very informal contact, but that was my way of maintaining a live interest in current ordnance problems and the research that was going on. I also did the same sort of thing with the Army Proving Ground at Aberdeen.*
>
> *When the national emergency [World War II] came on and the decision was made to move the ballistics work out of Washington from the Bureau of Ordnance to Dahlgren, the Postgraduate School was requested to transfer me to Dahlgren, but the Head of the Postgraduate School wouldn't agree, so they compromised by sending me to Dahlgren 4 days a week. That was the beginning of the ballistic work and the beginning of the Computation Laboratory because, at that time, there were only two mathematicians employed at Dahlgren. They were at about a GS-7 or GS-9 level. That was back about 1942, and there were also a couple of women at the GS-5 level.”*

Although he split his time between the Postgraduate School and Dahlgren for several years at that point, Prof. Bramble eventually moved to Dahlgren full-time in 1947 when he was appointed Head of the Computation and Ballistics Department. In 1951 he was selected as Dahlgren’s first Director of Research, a position he held until his retirement in January 1954.

Although Professor W. E. Bleick, 1946, and B. J. Lockhart, 1948, had also been involved with these computer developments before coming to the Department of Mathematics, it was Professor Church who led the movement to obtain the first electronic automatic digital computer. And so it was that in 1953, an NCR 102A, was hoisted by a crane through a second floor window in Root Hall and installed in the Mathematics Department. This precursor machine, as well as the development of its use in instruction and research, resulted in the acquisition in 1960 of the world's first all solid-state computer – the CDC 1604 Model 1, Serial No. 1 – which was designed, built, and personally certified in the lobby of Spanagel Hall by the legendary Seymour Cray. This was the first of ten such machines, ordered by the Navy's Bureau of Ships for its Operational Control Centers. The installation of the CDC 1604 coincided with the formation of the School's Computer Center, now named in honor of Professor Church.

Computer courses quickly became standard in almost every curriculum in the School, and the use of the computer in research work increased rapidly at the School. However, it was not until 1967 that the school established the Computer Science courses and began adding faculty in this area to the Department of Mathematics. Two years later, Gary Kildall joined the department as an instructor of mathematics to fulfill his draft obligation to the US Navy. His pioneering work during his years as part of the department fundamentally changed the nature of computing, particularly his creation of PL/M (the first high-level language developed for microprocessors) and CP/M (the first operating system for microcomputers).

Eventually, the existence of a group of computing specialists within the Department of Mathematics and their interaction with faculty in other departments (chiefly electrical engineering) who worked with computers led to formation of the Computer Science Group in 1973; however, the professors involved maintained their status in the Department of Mathematics until 1976 when the Department of Computer Science was formed. At that time, five faculty members moved from Mathematics to the new department.

Thus, in about thirty years, the Department of Mathematics had seen two sub-disciplines emerge and develop into thriving departments, each with its own cadre of graduate students, student thesis effort, and sponsored research.

Following the separation of Computer Science from Mathematics, the department saw a ten year period where it was functioning once again almost exclusively as a service department. The Mathematics curriculum (380), which had been established in 1956, was officially disestablished in 1976. The department maintained its degree granting authority, but without an official curriculum, only a handful of students received the MS in Mathematics between 1976 and 1987; most of these were dual majors with Operations Research.

The 380 curriculum was reestablished in 1987, and this initiated a period of growth in the department. More than half of the current faculty were recruited in the seven year period following the reestablishment of the curriculum. Throughout the 1990s, the department graduated an average of roughly six students per year with a steady mix of inputs from the Navy, Army, and Marine Corps.

In early 2001 the superintendent, RADM Ellison, officially closed the 380 curriculum ,ostensibly due to low Navy enrollments. Although the department maintained its degree granting authority, RADM Ellison did not allow other services to matriculate students in Applied Mathematics during the remainder of term, and this led to the loss of student inputs from the Army and Marine Corps. Upon his departure, the new superintendent, RADM Wells, officially changed the enrollment policy and allowed other services to matriculate in Applied Mathematics. Unfortunately, he was not able to get the 380 curriculum officially reinstated, and hence Navy students are still unable to enroll in the curriculum. In spite of this, the department has been able to somewhat rebuild our program, and in the last two years we have started to produce a small but steady stream of graduates.

NOTABLE VISITING PROFESSORS

- 1957-8: Prof. William Edmund Milne
- 1981-2: Prof. Garret Birkhoff

DEPARTMENT CHAIRMEN

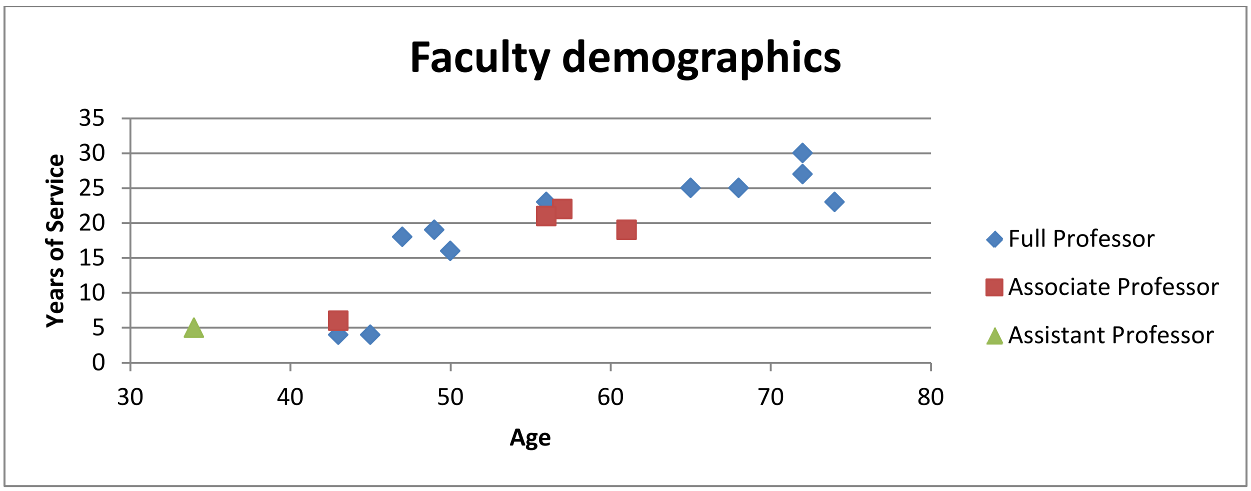
Although there were no official academic departments at NPS prior to 1946, Ralph Root is generally considered to be our first chairman as his original appointment to NPS was as head of mathematics and mechanics. Having held that post from 1914 until his retirement in 1946 we honor him by placing him first in our historical list of the chairmen of the department.

- 1914-1945: Ralph E. Root
- 1946-1965: W. Randolph Church
- 1966-1971: Robert E. Gaskell
- 1972-1973: W. Max Woods
- 1974-1975: Ladis D. Kovach
- 1976-1983: Carroll O. Wilde
- 1984-1986: Gordon E. Latta
- 1986-1992: Harold M. Fredricksen
- 1993-1996: Richard H. Franke
- 1996: Guillermo Owen
- 1997-1998: W. Max Woods
- 1999-2002: Michael A. Morgan
- 2003-2008: Clyde L. Scandrett
- 2009-Present: Carlos F. Borges

OVERVIEW OF THE FACULTY

TENURE-TRACK FACULTY

At the present time the department has sixteen tenured and tenure-track faculty, one of whom has been on an extended leave of absence since 2006. This number of faculty actually matches the number onboard back in 2001, although there have been four new hires in that period to replace retiring faculty members. There is good diversity among the tenure track faculty represented by three females and three Hispanics. This distribution of 19% in each category is well above the NPS averages (from the peer comparison study) of 16% and 11% respectively. And although we are under the peer institution median of 30% female, we are well above the peer institution median of 13% for underrepresented minorities. Indeed, we clearly have the most diverse faculty of any department in the School of Engineering and Applied Sciences. The chart below shows the age and years of service distribution for the tenure-track faculty.



A complete listing of the faculty as well as links to brief vitae and personal web pages can be found in Appendix A. Several major school wide research and teaching awards have been won by our current tenure-track faculty, including three Menneken Awards and one Schieffelin Award. A summary of major awards and prizes won by our faculty is available in Appendix B.

RESEARCH FACULTY

The department currently has two non-tenure track research faculty members. Distinguished Visiting Professor Art Krener has been resident with us since 2005. In 2009 Professor Margaret Cheney joined us as a Research Professor. Although her primary focus is her regular appointment as Professor of Mathematical Sciences at the Rensselaer Polytechnic Institute, she has ongoing interdisciplinary collaborations here at NPS, and her appointment is facilitating further collaborations both inside and outside of the department.

LECTURERS AND SENIOR LECTURERS

The department employs two lecturers and one senior lecturer. Although their main focus is teaching the remedial undergraduate mathematics courses that are essential to the transition of NPS students to the various science and technology curricula, all of them have a range of abilities well beyond that (one routinely teaches a graduate level dynamics class for the Meteorology department). The quality of teaching from this group of faculty is uniformly excellent and, indeed, one of them is a Schiefellin Award winner. All three are retired O-5 military officers (one each from the Army, Navy, and Air Force) and, as a result, are much attuned to the particular needs of our students.

In addition to classroom teaching, many are involved in curriculum reform efforts (course development, review sessions, textbook and lab-manual writing etc.).

DEPARTMENTAL POLICY ON INSTRUCTIONAL WORKLOAD

The departmental policy on instructional workload follows the fact that NPS is obligated, by contract, to pay all tenure-track faculty for ten months each year. Since the school operates year-round and there are four academic quarters, each tenure-track faculty member has one quarter each year (called their inter-sessional quarter) during which they are paid only one month of direct salary and must either find external funding or take leave without pay for the other two months. During the three quarters in which they are on a full-time pay status, each faculty member is required to teach a total of five sections as assigned by the chair.

Beginning in academic year 2009, the school offered another option for faculty. In particular, a faculty member who asks for only nine months of direct funding from the school is required to teach only four sections during that time. Faculty exercising this nine-month option are expected to secure external funding or take leave without pay for the entire three months of their inter-sessional quarter.

Faculty choosing the nine-month option may 'buy out' of additional teaching duties by securing more external funding. In particular, a faculty member may, with the permission of the chair, buy out of one additional class (reducing his/her annual load to three) by securing thirty-three days of additional external funding within the nine month window.

Lecturers are expected to teach at least two sections in each quarter that they are being paid from direct funds. There is no guarantee of employment in any quarter, and the number of days they are paid in any quarter may vary depending on workload.

Faculty who engage in certain paid administrative duties have reduced teaching loads (e.g., the chair does not have a teaching obligation while serving as chair).

FACULTY MENTORING

The department has a formal mentoring process for assistant professors to help them on their academic journey. Upon arrival at NPS and after a brief settling in period, the Chair assigns each assistant professor a two-person mentoring team. The mentoring team always has at least one full professor as the senior member. The mentoring team is tasked with helping the mentee develop the basic framework for a rich and rewarding academic career. This includes helping them:

- Adapt to the unique teaching demands of the school
- Develop a strong and relevant research program
- Understand the role of NPS in the Navy and DoD
- Balance the three pillars of teaching, scholarship, and service

The mentor team generates a mentor report each year after the mentee has submitted his or her faculty activity report. The mentor report summarizes the progress that the candidate is making toward promotion and tenure and is used by the Chair and the department as part of the annual renewal review.

OVERVIEW OF THE GRADUATE PROGRAM

MISSION

The Graduate Program in Applied Mathematics is designed to meet the needs of the Department of Defense for graduates who are skilled in applying concepts from advanced mathematics to real world military problems. A typical follow on assignment for graduates is to be an instructor in mathematics at the U.S. Naval Academy at Annapolis or the U.S. Military Academy at West Point. Program requirements are based on the premise that graduate students should have broad exposure to graduate level mathematics combined with hands-on experience, either through research activities conducted within the department or through coordinated experiences with other departments and other partners in industry, government labs, and national research institutes. To achieve this goal, we offer a spectrum of courses aimed at providing breadth of training, in addition to a depth of knowledge in one of the areas of specialization represented within our research ranks.

DEGREE PROGRAMS

In addition to the Master of Science and Doctor of Philosophy programs in Applied Mathematics, the department offers individually tailored minor programs for many of the school's doctoral students.

MASTER OF SCIENCE IN APPLIED MATHEMATICS

In order to enter a program leading to the degree Master of Science in Applied Mathematics, the prospective student is strongly advised to possess either a bachelor’s degree with a major in mathematics or a bachelor’s degree in another discipline with a strong mathematical orientation.

Any program that leads to the degree Master of Science in Applied Mathematics for a student who has met the entrance criteria must contain a minimum of 32 quarter-hours of graduate-level (3000-4000 numbered) courses with a minimum QPR of 3.0. The program specifications must be approved by both the department Chairman and the Academic Associate. The program is subject to the general conditions specified in the Academic Council Policy Manual as well as the following:

A student must complete or validate the four course 1000 level calculus sequence and the introductory courses in linear algebra and discrete mathematics.

The program must include at least 16 hours in 3000-level mathematics courses and 16 hours of approved 4000-level mathematics courses.

Courses in Ordinary Differential Equations, Real Analysis, and upper division Discrete Mathematics are specifically required, and those at the 3000 level or above may be applied toward the requirement above.

An acceptable thesis is required. The Department of Applied Mathematics permits any student pursuing a dual degree to write a single thesis meeting the requirements of both departments, subject to the approval of the Chairmen and Academic Associates of both departments.

DOCTOR OF PHILOSOPHY IN APPLIED MATHEMATICS

The Department of Applied Mathematics offers the degree Doctor of Philosophy in Applied Mathematics. Areas of specialization will be determined by the department on a case by case basis. Requirements for the degree include course work followed by an examination in both major and minor fields of study, and research culminating in an approved dissertation. It may be possible for the dissertation research to be conducted off-campus in the candidate's sponsoring organization.

Entrance into the program will ordinarily require a master's degree, although exceptionally well-prepared students with a bachelor's degree in mathematics may be admitted. A preliminary examination may be required to show evidence of acceptability as a doctoral student. Prospective students are directed to contact the Chairman of the Applied Mathematics Department or the Academic Associate for further guidance.

CERTIFICATE PROGRAMS

In recent years the department has created two certificate programs wherein students can earn a certificate by completing a prescribed program of coursework. The first of these was the Mathematics of Secure Communications Certificate (curriculum 280) which was created in 2003. This certificate program has become very popular with students from a variety of curricula. Second was the Scientific Computation Certificate (curriculum 283) which was launched in 2009. We are currently moving our first cohort of students through this program and have high hopes for its future success, particularly as a coherent minor program for doctoral students in the various engineering programs on campus.

STUDENT BODY PROFILE

Our production of graduates has been severely impacted by the official elimination of the 380 curriculum in 2001. Although the curriculum is still officially inactive for Navy students, we reopened the master's degree program for student inputs in 2006 at the direction of then President RADM Wells. This allowed us to begin admitting Army students and since that time our output has increased dramatically and we have graduated an average of more than seven students per year (master's, dual master's, and doctorate) since 2007.

A detailed list of graduates for the past five years along with their thesis titles appears in Appendix D.

OVERVIEW OF THE INSTRUCTIONAL PROGRAM

OUR CAMPUS ROLE

The department currently enrolls more than 1,200 students in roughly 80 sections of mathematics courses per year. Less than two percent of these enrollments are math graduate students. Thus the magnitude of our service role to the university is huge and we take our service mission very seriously. Technical majors, either engineering or science, usually take four or more mathematics classes. In sum, we support 30 separate curricula at NPS:

- 356 - Information Systems & Operations
- 360 - Operations Analysis
- 361 - Joint Operational Logistics
- 362 - Human Systems Integration
- 363 - Systems Analysis (DL)
- 365 - Joint Cmd, Cntrl, Comm, Comp/Intel (C4I) Sys
- 366 - Space Systems Operations
- 368 - Computer Science
- 370 - Information Systems & Technology
- 372 - Meteorology
- 373 - Meteorology and Oceanography (METOC)
- 380 - Applied Mathematics
- 399 - Modeling, Virtual Environments & Simulation
- 525 - Undersea Warfare
- 533 - Combat Systems Sciences & Technology
- 570 - Naval/Mechanical Engineering
- 580 - Systems Engineering
- 590 - Electronic Systems Engineering
- 591 - Space Systems Engineering
- 595 - Information Warfare
- 596 - Electronic Warfare Systems International
- 814 - Transportation Management
- 815 - Acquisitions & Contract Management
- 816 - Systems Acquisition Management
- 819 - Supply Chain Management
- 820 - Resource Planning/Mgmt for International Defense
- 827 - Material Logistics Support Management
- 837 - Financial Management
- 870 - Information Systems Management MBA
- 999 - Staff (Non-Degree)

Our core teaching load can roughly be split into three tracks:

Calculus Refresher Track – This consists of four classes (MA1113, MA1114, MA1115, and MA1116) covering single-variable, multi-variable, and vector calculus (although there are some variations). These classes are generally taught in a highly accelerated mode so that they can be completed in the first two quarters. This track is taken by students in most technical curricula (i.e., a significant proportion of all students from GSEAS and GSOIS) although those with sufficiently strong backgrounds may validate some or all of these classes. Annual enrollments in this group during 2009 were 550 as compared with 622 in 2006. This decrease of more than 10% is very significant and reflects the large decrease in enrollments in the Engineering school over the past three years.

Core Analysis Track - This consists of the core undergraduate analysis classes that are essential in physical sciences and engineering. The basic courses are Ordinary Differential Equations (MA2121), Partial Differential Equations (MA3132 or MA3139), Linear Algebra (MA2043 and MA3046), and Numerical Analysis (MA3232). Courses from this track are generally taken by students from GSEAS. Enrollments in this track are highly variable and in decline due to collapsing enrollments in GSEAS curricula.

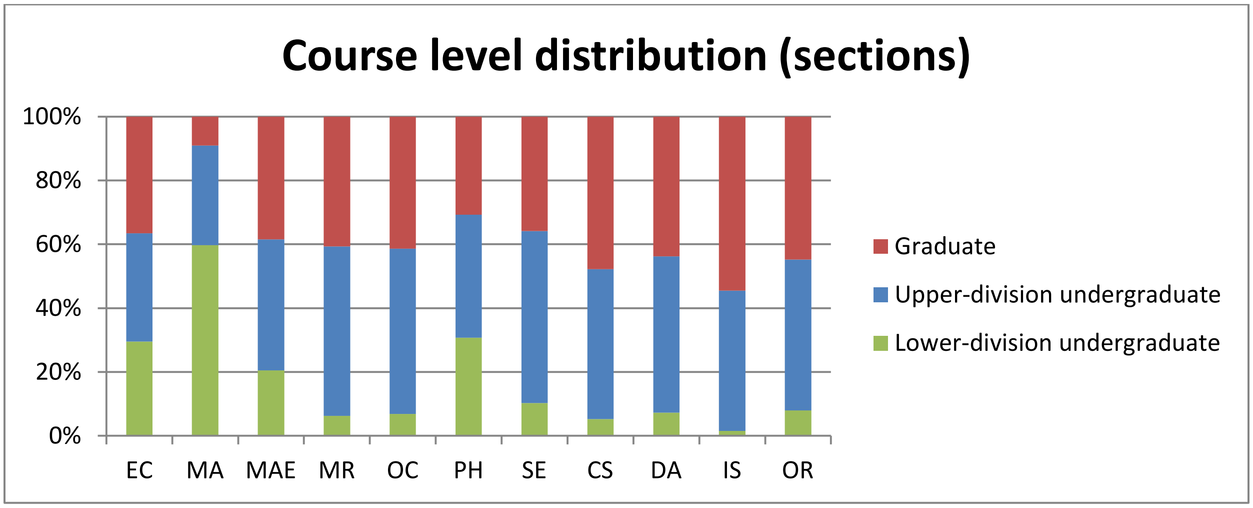
Core Discrete Mathematics Track – This consists of core classes in mathematics essential in computer science and operations research. The courses in this track are Discrete Mathematics (MA1025, MA2025, and MA3025) and Linear Algebra (MA3042). Courses in this track are generally pursued by students from GSOIS. Enrollments in this track have been relatively stable.

TEACHING PROFILE

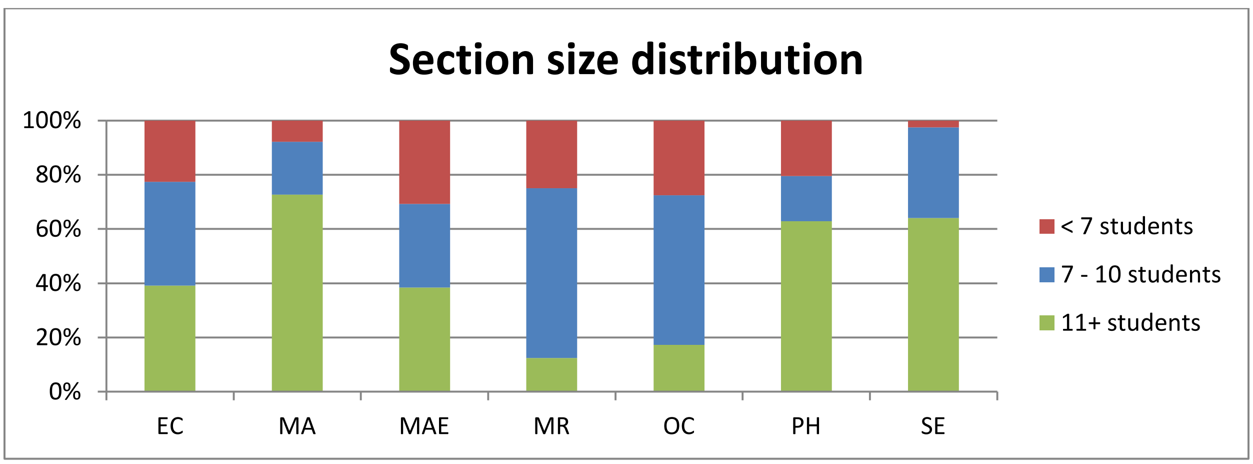
The nature of the teaching effort within the department is significantly different than that of other technical departments on campus both within GSEAS and GSOIS. To better understand this, consider the following table which summarizes the distribution of resident sections by course content level for the 2009 academic year. The table is separated into two parts, the GSEAS departments and then the GSOIS departments (which include OR and CS, both of which were at one time part of MA).

Level	EC	**MA**	MAE	MR	OC	PH	SE	CS	DA	IS	OR
4000	42	**7**	30	13	12	24	14	64	42	36	56
3000	39	**24**	32	17	15	30	21	63	47	29	59
2000	30	**10**	15	2	2	13	2	7	7	1	8
1000	4	**36**	1			11	2				2
Total	115	**77**	78	32	29	78	39	136	96	66	125

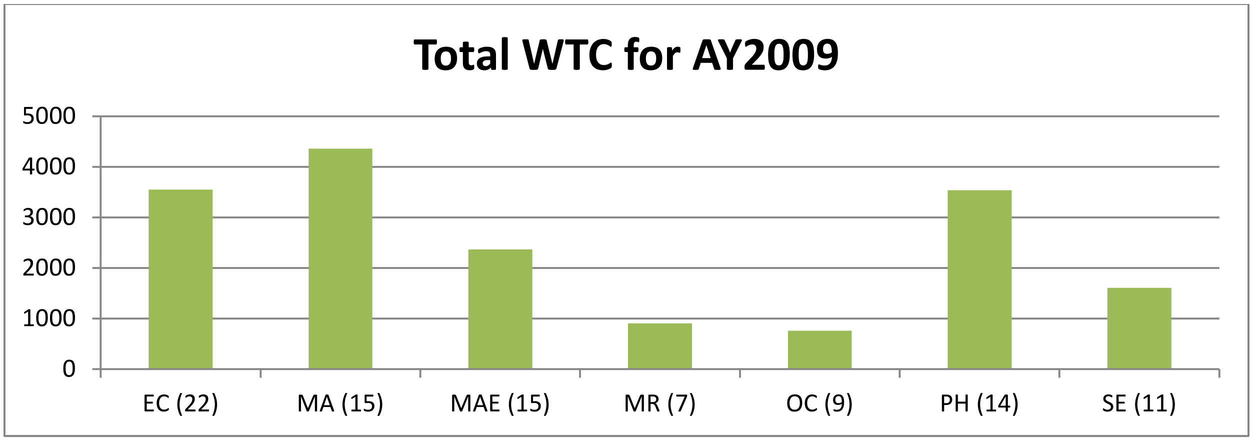
It is very clear from the data that the teaching experience for faculty in Applied Mathematics is very different than it is in other technical departments. A few things bear special mention. First of all, we teach a tremendous number of sections at the first year undergraduate level. Indeed, we taught 36 of 56 total such sections on campus in 2009, nearly 65% of all sections at that level. Second, no technical department on the entire campus teaches fewer sections of graduate level material. Indeed, every other technical department taught a minimum of 35% of their sections at the 4000 level, compared to just 9% in Mathematics. Even departments teaching half as many total sections as we do, still teach nearly twice as many sections at the 4000 level. The following bar graph summarizes this by showing the percentage distribution of teaching efforts at the graduate (4000), upper-division undergraduate (3000), and lower-division undergraduate (1000 and 2000) levels.



Another important factor which impacts the teaching profile is the size of class sections. Consider the following bar chart which summarizes the distribution of resident class section sizes for all GSEAS departments for 2009.

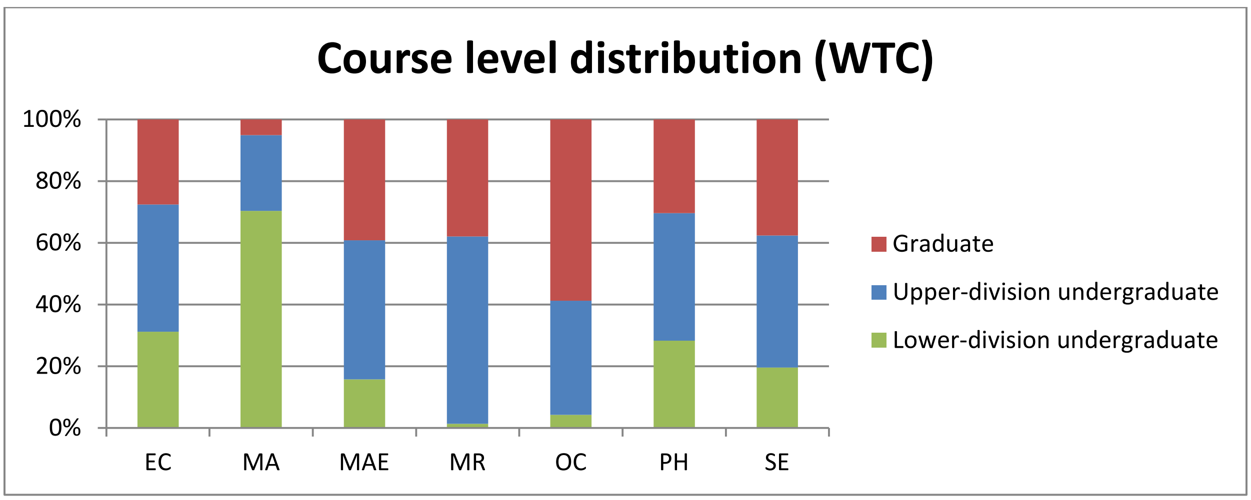


This chart shows how very different the teaching loads are in the department. We teach many more large classes which is extremely demanding in an institution where there are no teaching assistants, homework graders, etc. To get another perspective on this issue we can examine teaching in AY2009 by weighted teaching credit (WTC). Weighted teaching credit is computed by multiplying the number of students in a section by the number of lecture hours and then summing over all sections. The following chart summarizes teaching in AY2009 by weighted teaching credit for resident sections only across all seven GSEAS departments.



The number to the right of each department indicates the number of tenure-track faculty in that department for AY2009. The much higher real teaching loads in mathematics are readily apparent. Indeed, we teach nearly twice as much as MAE with the same number of tenure-track faculty.

The chart below shows the combined effect of large class sizes and low class level. It summarizes the distribution of teaching by weighted teaching credit at the various levels.



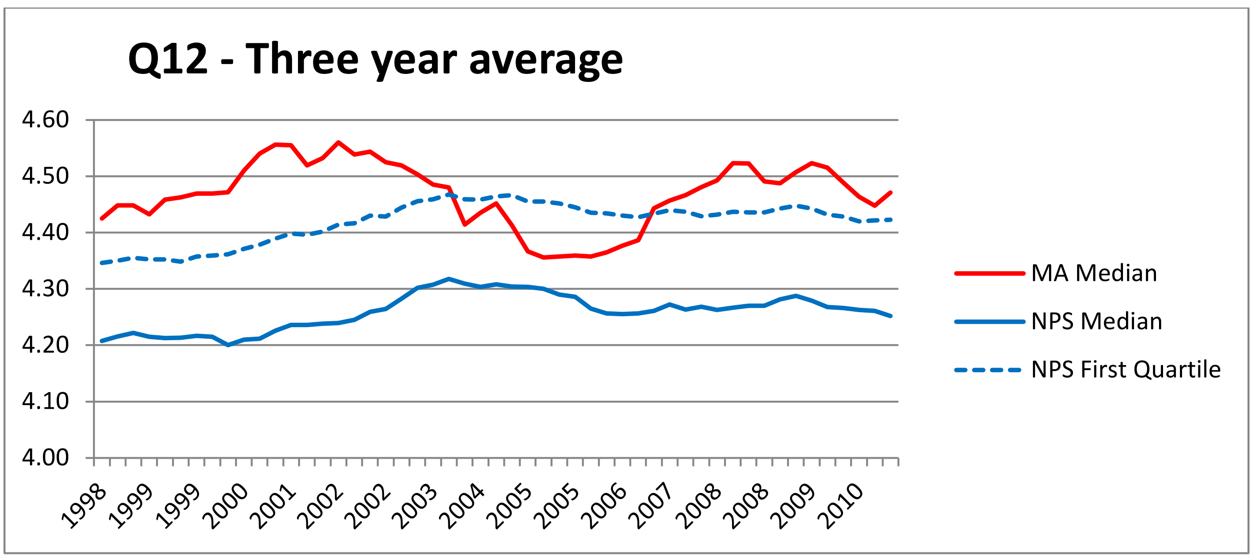
The contrast in teaching profiles is both clear and critical. The Department of Applied Mathematics is unique in that we do more than 70% of our teaching at the first and second year undergraduate levels (1000 and 2000). This impacts faculty careers in several ways. First, the extremely limited graduate level teaching makes it far more difficult to develop and maintain active research programs. Second, the incredible demands of fast-paced remedial undergraduate level teaching makes classroom excellence a far more critical issue in promotion and tenure decisions than in other departments. Third, the time demands of teaching large sections of remedial mathematics to students just returning to university studies leaves little time to pursue research during teaching quarters (it is common for tenure-track faculty in mathematics to log more weighted teaching credit in a single quarter than tenure-track faculty in other departments log in an entire year). All of these issues are amplified by the widely varying levels of preparation of incoming students (including, direct entry students who often come straight into multi-variable calculus without a refresher quarter in which to relearn basic single variable calculus).

One final note is that none of the preceding includes any counting or consideration of reading classes. This is another burden on the faculty since the department generally offers six to ten such classes each year and they are not accounted for in any way (i.e. no funding or other credit is given).

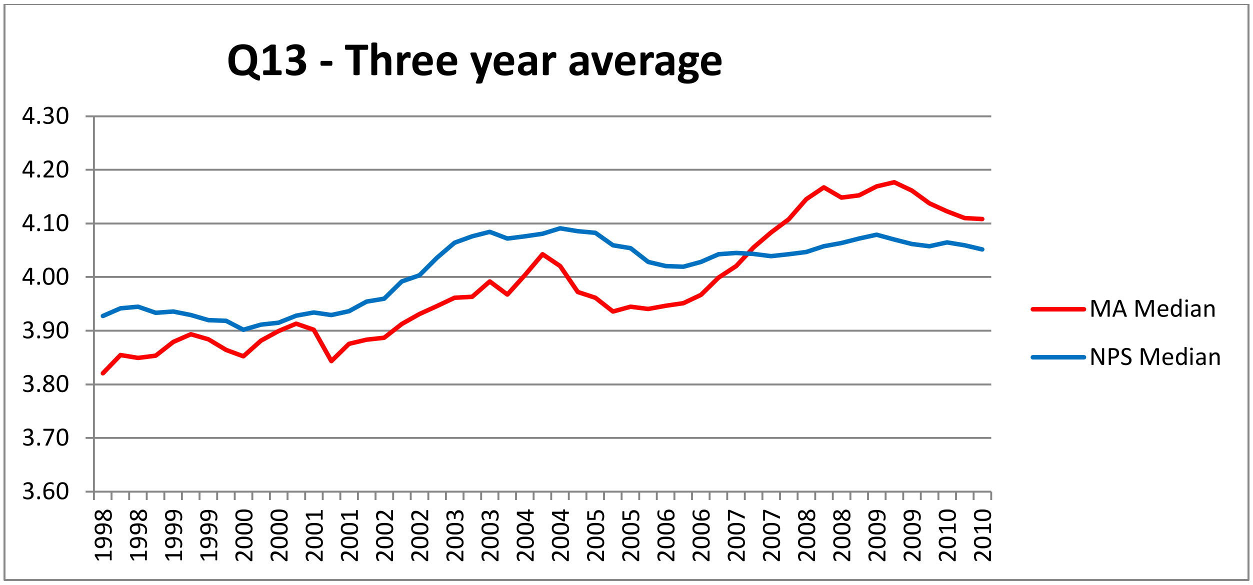
INSTRUCTIONAL EVALUATION AND ASSESSMENT

The core campus process for evaluating instruction is the Student Opinion Form (SOF). This is a Likert scale survey instrument that is administered at the end of every quarter in every class section. The survey is administered electronically and the data is centrally collected for use in a wide variety of evaluation and assessment processes. Although there are sixteen questions on the survey, two are of particular importance. Question twelve (Q12) asks “Overall, I would rate this instructor:” and allows for a rating from one to five with one indicating “Lowest 10%” and five indicating “Top 10%”. Question thirteen (Q13) asks “Overall, I would rate this course:” with the same rating scale.

One method of evaluating the department’s instructional performance is to examine the results from these two questions in comparison with the rest of the school. Because the data is a bit noisy, one gets a clearer picture by considering a moving average. The tables below show three-year moving averages of the data comparing the median performance of the department to the school-wide median performance.



Not only is our median rating uniformly far above the campus-wide median, it is nearly always comfortably above the campus-wide first quartile. This reflects the strong emphasis placed on individual instructional performance within the department. What makes this even more noteworthy is the fact that it is done while teaching a high proportion of large, accelerated pace, remedial undergraduate classes.



This graph also shows excellent performance by MA. We have made a concerted effort in the last several years to tighten up our syllabi and improve our offerings. The table above clearly shows that those efforts have paid off in increased ratings of our courses. One should note that NPS as a whole has remained relatively stagnant in this measure for about eight years.

RELATIONS WITH CLIENT DEPARTMENTS

We maintain an ongoing dialogue with other client departments to make sure our courses continue to serve their needs. In addition, the Mathematics Department is heavily involved with the accrediting process for Engineering through ABET (the Accrediting Board for Engineering Technologies). This process involves examining our course syllabi, textbooks, and sample exams in our engineering mathematics courses.

Mathematics faculty are also heavily involved as advisors and co-advisors for master's and Ph.D. students all across campus. This further strengthens our relationships with these departments and has even led to several joint appointments over the years.

OVERVIEW OF THE RESEARCH PROGRAM

RESEARCH GROUPS

The department's research efforts can be grouped into three broad areas, as delineated below. These areas have considerable overlap and several faculty consider themselves associated with more than one group. Beyond the areas listed below, a number of researchers from the department have major interdisciplinary connections to researchers from other departments across the campus. Indeed there are very prominent collaborations with the departments of Computer Science, Defense Analysis, Electrical and Computer Engineering, Mechanical and Aerospace Engineering, Meteorology, Oceanography, Operations Research, and Physics.

APPLIED ANALYSIS

Applied analysis is concerned with the interface between fundamental mathematical structures which rely on continuity and their use in the physical and social sciences. This research group has diverse interests that include asymptotic analysis, control theory, mechanics (fluid and orbital), and game theory. There are significant overlaps with the research group in Numerical Analysis/Scientific Computing.

Regular Faculty Members in the Applied Analysis Group

- Don Danielson
- Chris Frenzen
- Wei Kang
- Art Krener
- Guillermo Owen
- Clyde Scandrett

Current Postdoctoral Members in the Applied Analysis Group

- Cesar Aguilar

NUMERICAL ANALYSIS / SCIENTIFIC COMPUTING

Numerical Analysis/Scientific Computing is the study of theories, computational methods, numerical algorithms, and other tools required to practically solve mathematical models of problems from science and engineering in a fast, accurate, and efficient manner. The primary goal is the development of novel techniques and approaches to approximation and efficient computation that are at the heart of modern science. This research group is primarily focused on the numerical solution of partial and ordinary differential equations, numerical linear algebra, and approximation theory. There are very significant overlaps with the research group in Applied Analysis.

Regular Faculty Members in the Numerical Analysis / Scientific Computing Group

- Carlos Borges
- Fariba Fahroo
- Frank Giraldo
- Bill Gragg
- Beny Neta
- Hong Zhou

Current Postdoctoral Members in the Numerical Analysis / Scientific Computing Group

- Jim Kelly
- Shiva Gopalakrishnan
- Eric Choate

DISCRETE MATHEMATICS

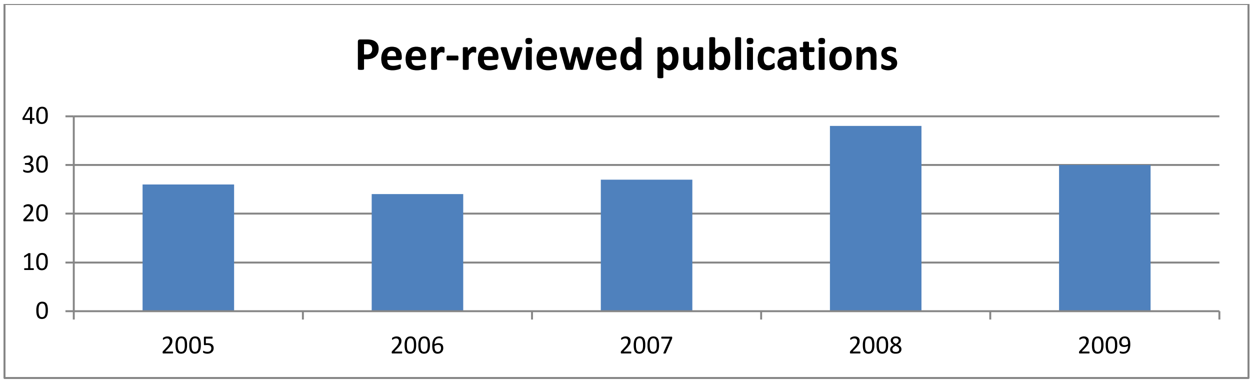
Discrete mathematics, sometimes called finite mathematics, is the study of mathematical structures that are fundamentally discrete, in the sense of not supporting or requiring the notion of continuity. Discrete mathematics is extensively used in a variety of critical applications such as cryptography, coding theory, combinatorics, network analysis, and search algorithms for the internet.

Regular Faculty Members in the Discrete Mathematics Group

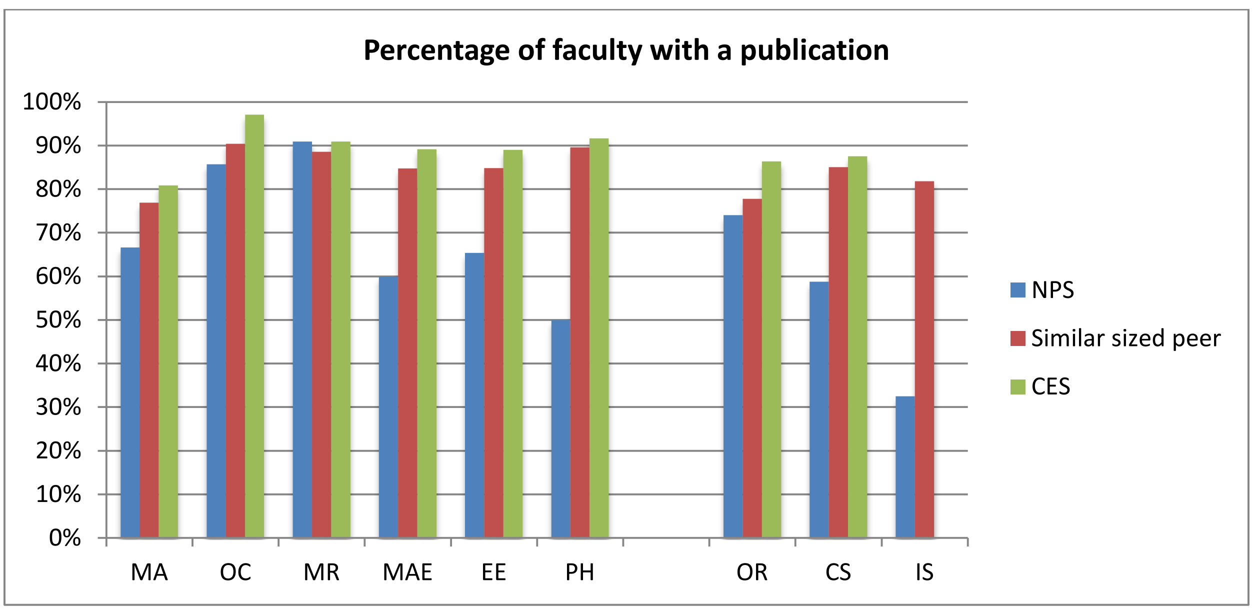
- David Canright
- Hal Fredricksen
- Ralucca Gera
- Craig Rasmussen
- Pante Stanica

RESEARCH OUTPUT

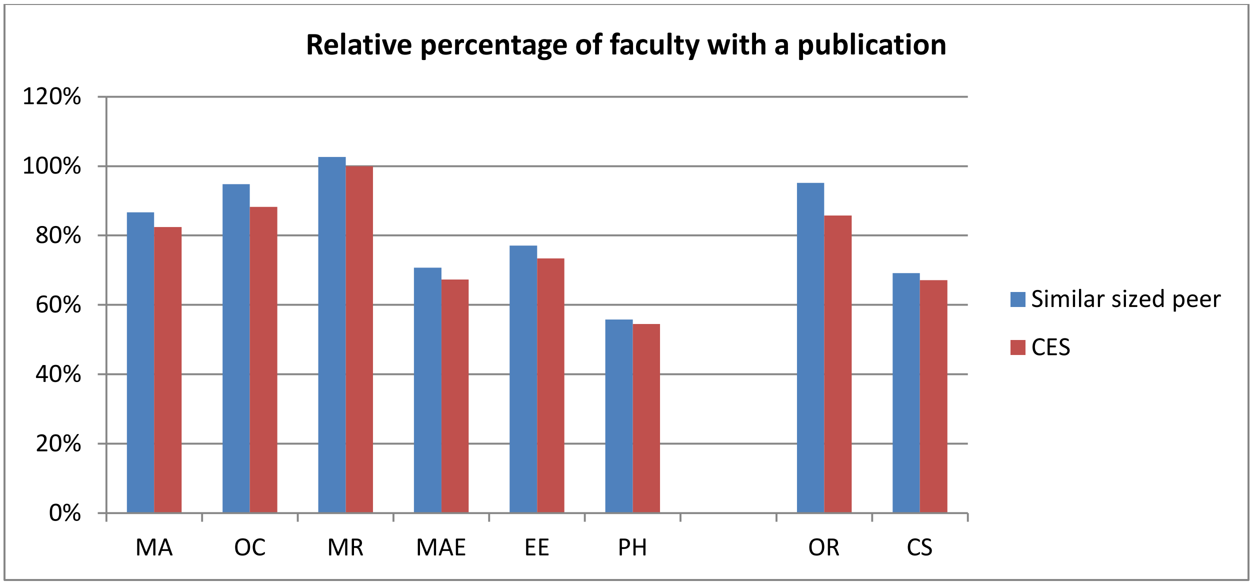
Department research output in terms of peer-reviewed publications is excellent. A comprehensive list of our peer-reviewed publications for the years 2005 to 2009 can be found in Appendix C. The table below summarizes the total annual output of peer-reviewed publications by our tenure-track faculty over the same period.



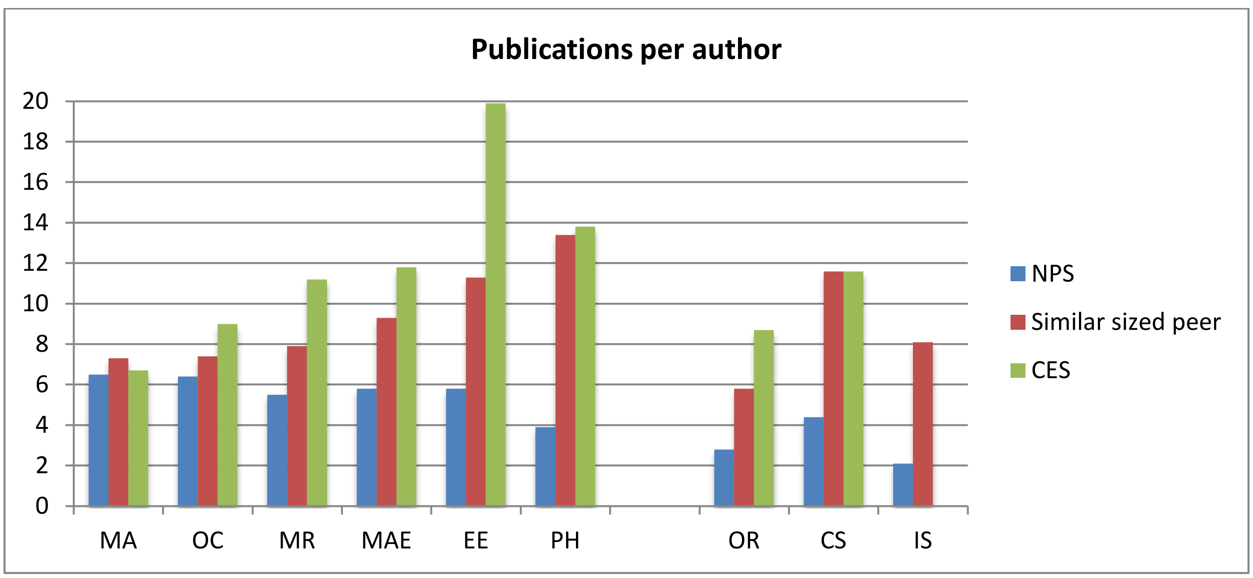
We can paint a more useful overall picture of published research output by looking at data from the recent peer comparison studies. Of particular note in the CES study is the fact that NPS, as a school, ranked dead last in terms of the number of journal articles produced, which indicates low aggregate productivity in this regard. However, when one breaks out the results of the AA2010 peer comparison study to the departmental level, we see that the Department of Applied Mathematics fares rather well against its peers. Note that there are generally two comparisons, first against all similar sized departments (same number of faculty ±5) from a database of over 300 other institutions, and then against the fifteen CES peers. The tables below show the most salient features in regards to publications and citations. Note that this data is collected by looking at publications from a selected set of sources over the three year period 2006-2008, and, hence, the total number of publications listed for each department is generally undercounted. On the other hand, the metric is consistent from institution to institution; hence, the comparisons are on the whole valid measures of the relative publication statistics. First of all we look at the percentage of faculty with a publication during the comparison period.



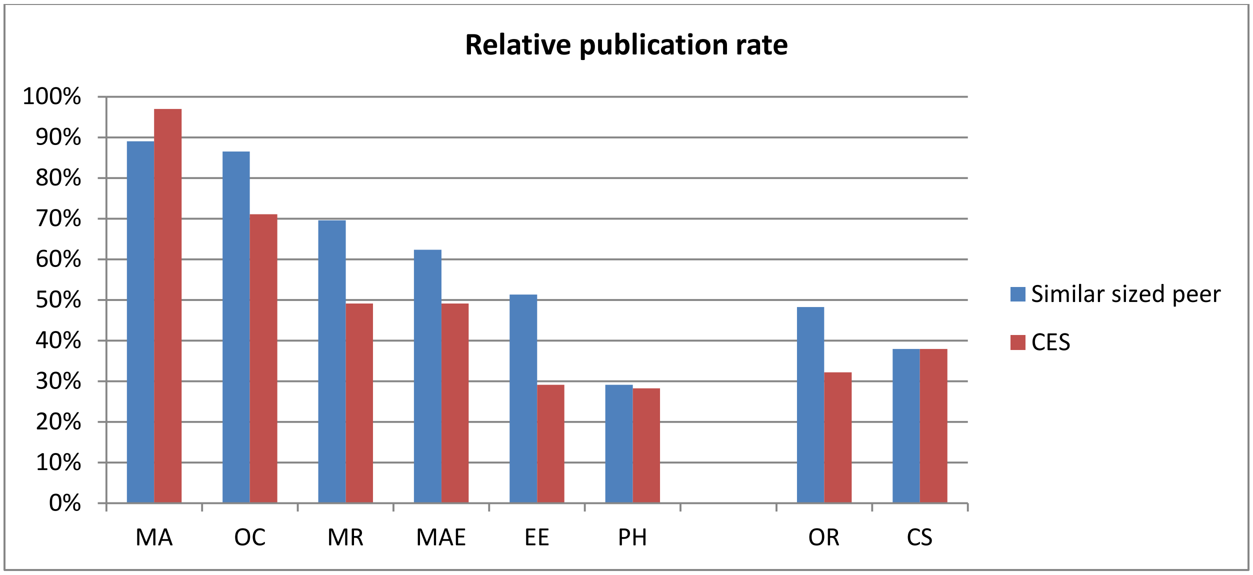
One can more readily compare by looking at the ratio of the NPS percentage to the CES and similar sized peer percentages as shown in this chart.



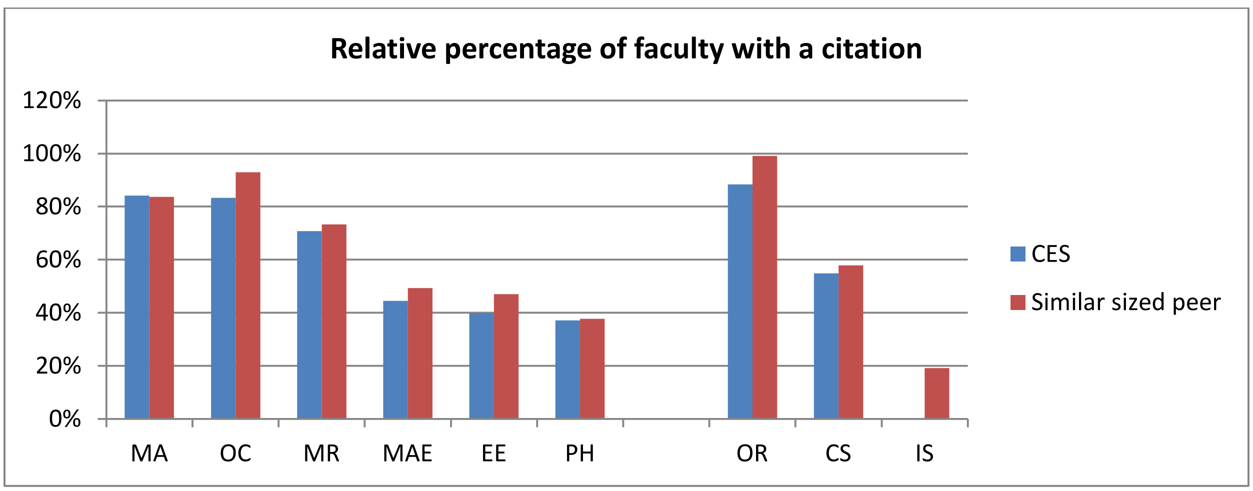
In light of the substantial teaching loads our relative performance in this category is quite good, particularly in comparison with other NPS technical departments. The only two GSEAS departments that outperform us are small, have minimal teaching loads, and have large numbers of research faculty. Next we look at publications per author from the same study.



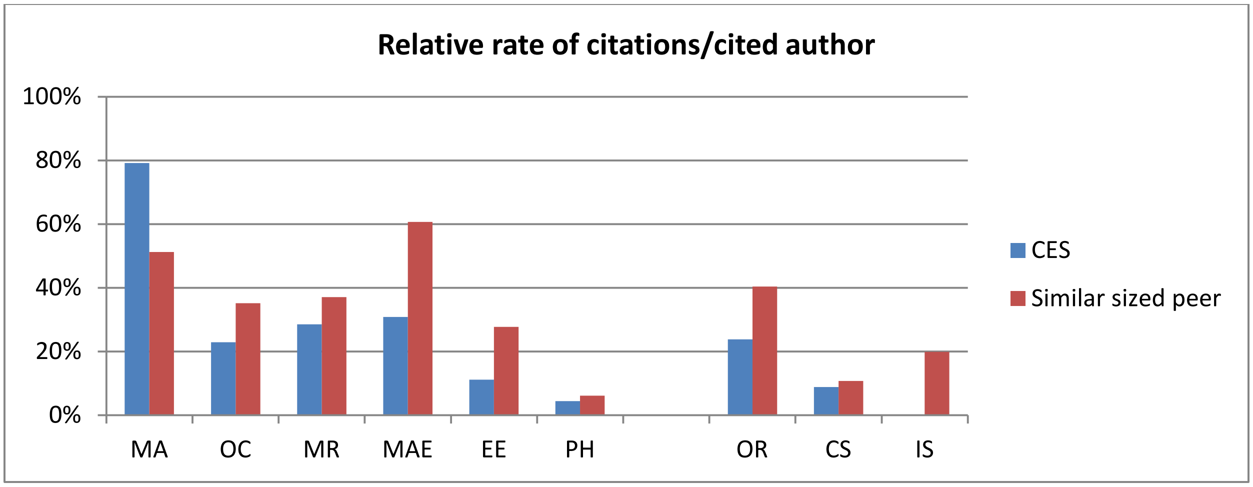
In this critical category we are ranked higher than any other department on campus- both in absolute terms and in comparison to our peers. This can be seen more readily by examining the relative publication rate (ratio of NPS average to peer group average) which is displayed below.



Finally, it is noteworthy that the work of math faculty is well cited in comparison to our peers. This can be seen in the two charts that follow. The first displays ratio between the percentage of our faculty with a citation and the same percentage for the peer groups.



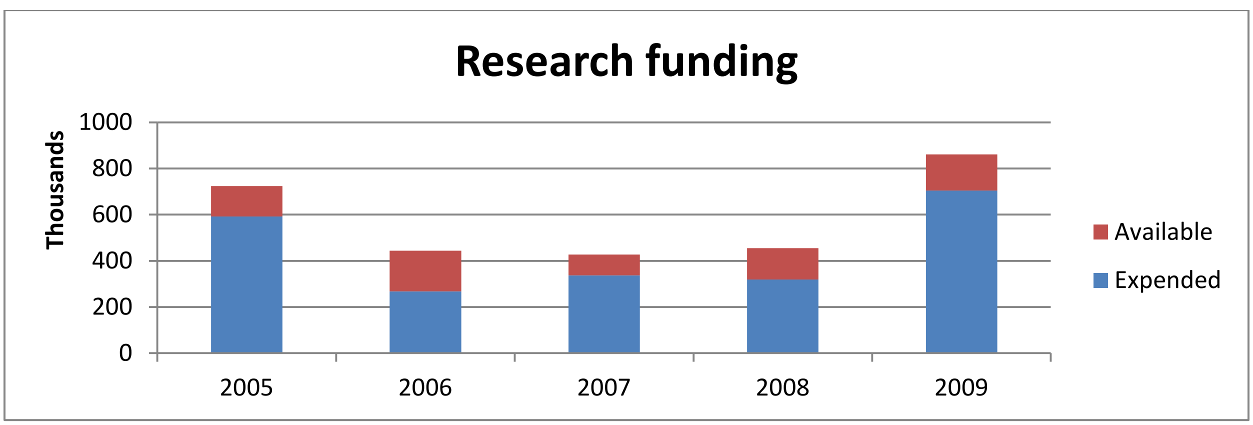
Note that we are clearly in the first tier of technical departments in this regard. The second chart shows the ratio of the number of citations per cited author between NPS and the peer groups. In some sense, the citation rate indicates the impact of a particular author's work and hence this is a critical measure of the importance of our work to the wider community of scientists.



Once again, in this critical area we are far stronger than the other technical departments on campus.

RESEARCH FUNDING

Collectively, the departmental research expenditures in 2009 total roughly $550,000 from external research funding, most of which comes from ONR and AFOSR, with lesser amounts from other DoN/DoD sources. Approximately one-third of the tenured and tenure-track faculty have direct federally funded grant support. This is slightly above average for mathematics faculty as documented in the *Science and Engineering Indicators*: 2010 (Table 5.12), which notes that only 29.7% of full-time mathematics faculty having doctoral degrees for at least four years received federal research support in 2009. Although this average is much lower than most other fields of science, it has been relatively stable in the field of mathematics for many years. It is also worth noting that several additional faculty are involved in externally funded research projects with principal investigators from other NPS departments. External funding expended by these faculty is not listed in the table below.



Unfortunately, efforts to attract external research funding are hampered by the lack of a sustainable graduate program and the effects of the high load of remedial undergraduate-level teaching.

POST-DOCTORAL PROGRAM

The department maintains an active post-doctoral program. We currently have four National Research Council post-docs residing in the department. Two are working with Prof. Giraldo in the area of Scientific Computing, one is working with Prof. Krener in the area of Applied Analysis, and one is working with Prof. Zhou in the area of Scientific Computing.

DEPARTMENTAL POLICY ON SCHOLARLY ACTIVITY

The departmental policy on scholarly activity has been crafted to support the mission of the Naval Postgraduate School, and in view of that supportive posture, our approach differs substantially from that of most civilian research universities. More specifically we view research and scholarship as a means rather than as an end in itself. In light of that, it is our policy that all tenure-track faculty shall be engaged in meaningful scholarly activity as part of their regular duties, and, furthermore, that such activity shall in some way support the mission of the school. As a department, we recognize that the unique nature of the Naval Postgraduate School carries with it very unique forms of meaningful scholarly activity and we acknowledge that this can be very difficult to assess. Moreover, we acknowledge that choosing simplistic numerical metrics would hinder our ability to contribute and could adversely affect the quality of our work. We strongly agree with the position of the American Mathematical Society and their published 2006 statement regarding this issue – "*When judging the work of most mathematicians, the key measure of value for a research program is the quality of publications rather than the rate.*"

OVERVIEW OF DEPARTMENTAL OPERATIONS

The department places a high premium on collegiality, and this is reflected in our internal structure and governance. The Chair is elected by the department faculty and serves for a term of three years after being appointed by the school's President upon the recommendation of the Provost. The department is strongly committed to a system of shared collegial governance. There are several standing committees, as outlined below, which recommend policies and actions on issues such as the curriculum, hiring, and admissions. All critical strategic decisions are made with the full participation of the faculty after study and recommendation by the appropriate committee (or a specially appointed committee if the issue does not naturally fall in the purview of one of the standing committees). Significant effort is made to constitute committees that are representative of the various groupings within the department (professorial rank, research area, etc.). Once major strategic decisions have been made by the department, the Chair is responsible for implementing them.

In addition to committee input, the Chair convenes general faculty meetings once or twice per quarter as necessary, and meets with individual committees on an as-needed basis.

GOVERNANCE STRUCTURE

- *Chair.* Carlos Borges – The Chair plans and administers the educational, personnel, and financial activities of the department. The responsibilities of the Chair include:
    - Organizing and supervising the department to carry out the educational policies of the school and to accomplish the objectives of the various curricula
    - Planning and supervising research programs in the departments to support the mission of the school.
    - Planning the academic program for the department
    - Representing the department in academic and administrative matters, including the annual Promotion and Tenure (P&T) activities
    - Recruiting qualified academic personnel for the department, within authorized allowances, and recommending their appointment
    - Recommending faculty for promotion, tenure, and merit pay raises
    - Providing professional evaluation of academic personnel and performance ratings of civil service personnel assigned to the department
    - Maintaining familiarity with related activities at civilian educational institutions and technical and industrial organizations, so that curricula and courses are kept abreast of educational and technical advances
    - Managing the departmental budget, and representing the department in school-wide budgeting processes
    - Overseeing the mentoring program for faculty.
    - Designating and supervising Associate Chairs to assist with departmental administrative duties
    - Working with the Program Officers in maintaining liaison with sponsors, developing new programs, and in the sponsor evaluation and modification of programs

- *Associate Chair for Instruction.* Bard Mansager - Appointed by and reports to the Chair; Primary responsibilities include:
    - Serves as Academic Associate
    - Oversees student admissions
    - Designs and oversees the course matrices of all Math majors
    - Oversees the department's teaching mission, including interface with client disciplines
    - Focal point for curriculum reform efforts of the department
- *Associate Chair for Research.* Frank Giraldo - Appointed by and reports to the Chair; Primary responsibilities include:
    - Oversees the department's research programs
    - Represents the department to the Campus Research Board
    - Coordinates research activities within the department
- *Associate Chair for Computing.* David Canright - Appointed by and reports to the Chair; Primary responsibilities include:
    - Oversees the department's computing facilities
    - Represents the department on the Campus Computing Advisory Board
    - Coordinates and oversees software licenses and other related issues
- *Colloquium Coordinator.* Art Krener – Appointed by the Chair
    - Oversees the departmental colloquium series
- *Library Liaison.* Hong Zhou – Appointed by the Chair
    - Serves as a liaison between the department and the Dudley Knox Library
- *Webmaster*. Ralucca Gera – Appointed by the Chair
    - Oversees the maintenance of the department web pages

STANDING COMMITTEES

- *Planning Committee.* Makes recommendations on long-range planning issues such as hiring, coordinated research efforts, and new initiatives. Responsible for creating and updating the department's strategic plan. The Associate Chair for Research is an *ex officio* member. Reports to the Chair.
- *Course and Curriculum Committee.* Assigns course coordinators to individual courses. Reviews class syllabi, curriculum materials, and other issues related to the department's teaching mission. Coordinates with client curricula to ensure that our course offerings continue to satisfy their requirements. Reports to the Associate Chair for Instruction.
- *Computing Committee.* Oversees computing issues within the department including the selection of instructional software. Reports to the Associate Chair for Computing.
- *Doctoral Committee.* Oversees all aspects of the doctorate program to include admissions, curriculum, selection of dissertation committees, and administration of qualifying examinations. Reports to the Chair.

STAFF

There are currently 2 staff members:

- *Administrative Support Assistant (ASA):* Bea Champaco - supervises office staff and is in charge of the department's financial operations.
- *Office Automation Assistant (OA):* Stephanie Muntean - assists department ASA with departmental operations and provides support to faculty.

COMPUTING SUPPORT

The Department of Mathematics computing infrastructure is consists primarily of individual Windows machines in faculty and graduate student offices. These are all connected to the campus ITACS infrastructure and they provide nearly all of our software and hardware support. The department replaces individual PCs on a three to four year cycle, although funding for this requirement is a continuing problem.

DEPARTMENTAL COMPUTING RESOURCES

Below is a summary of the workstations and servers that comprise the department's computing infrastructure.

- Approximately 30 PCs ranging from new to four years old
- Approximately 6 laptop computers
- One LCD projector
- One faculty member, Frank Giraldo, has a 4 Node, 32 Core Apple XServe cluster.

CAMPUS COMPUTING INFRASTRUCTURE

- High Performance Computing Center. This group promotes scientific computing at NPS by providing support to researchers and departments who wish to engage in scientific computing, and aims to establish NPS as a nationally recognized HPC "Center of Excellence." The group’s high-performance computing facility provides a powerful baseline of computation and storage infrastructure, including scientific workstations, supercomputer systems, high speed networks, special purpose and experimental systems, the new generation of large scale parallel systems, and application and systems software with all components well integrated and linked over a high speed network.
- ITACS. The Information Technology and Communications Services (ITACS) name reflects the incorporation of all communication services, telephone support, and network support into the core computing functions that have been provided by the Naval Postgraduate School since 1953.

ASSESSMENT, EVALUATION, PROMOTION, AND REVIEW PROCEDURES

All faculty and staff are evaluated annually for purposes of determining merit raises and to maintain an ongoing dialogue regarding their personal goals and their role in the development of the department. In addition, our curriculum, certificates, and courses are overseen by the appropriate committee and/or administrative member of the department. Below is a summary of how the faculty, staff, and programs are evaluated and assessed.

REVIEW PROCESS FOR FACULTY

Each faculty member is required to submit quarterly workload forms outlining their planned activities at the beginning of each quarter. At the end of the calendar year each faculty member compiles and submits an annual Faculty Activity Report (FAR) which summarizes their accomplishments in the prior year. The Chair is in charge of evaluating the faculty on the basis of the quarterly workload forms, the annual Faculty Activity Reports, and other information that may be pertinent for the year (e.g. student opinion form data). These evaluations take into consideration the contributions made to teaching, research, and service. Teaching evaluation includes classroom performance, as well as the impact of any course development or reform efforts (either within the department or elsewhere). The effectiveness of classroom performance is largely determined by reviewing data from the student opinion form although classroom visits by the Chair or other faculty (e.g. members of the mentoring team for Assistant Professors) may also be used. For research, the emphasis is on determining the impact of the faculty member's work, measured using the guidelines and principles set forth in the Marto Report and the Powers Report. Although this approach is far more demanding than simply counting papers or adding up grants, it is essential due to the very non-traditional nature of the Naval Postgraduate School. Service includes departmental committee work, as well as service to the school (e.g. faculty council), service to the profession (e.g. conference organization), and service to the community (e.g. outreach activities). Certain activities overlap multiple criteria. For example, the directing and mentoring of graduate students contributes to both the teaching and research missions of the department. As another example, conference organization is a service to the profession, but it also enhances and facilitates the organizer's research program.

Each tenured or tenure-track faculty member is rated on a scale of Meritorious or Unsatisfactory in accordance with the school’s human resources office (HRO) procedure. There are no fixed percentage weights on the contributions of research, teaching, and service. In addition, junior faculty, are not expected to perform much service (though many are involved in conference organization and outreach activities). Each faculty member discusses his or her evaluation with the Chair annually.

Lecturers and senior lecturers are also evaluated by the Chair. The evaluation criteria include classroom teaching, the impact of course and curriculum development (e.g. developing militarily relevant example problems or demonstrations), and service (e.g. course coordination, review sessions, help-session coordination).

In early 2010, the current chair created a new internal review process by which the faculty evaluate the chair. This process is in its infancy, but uses an anonymous web based survey tool that is implemented using Google documents (a dummy copy is viewable here). There are a number of statements which are ranked on a Likert scale (strongly disagree to strongly agree) as well as questions which allow anonymous written responses and suggestions. Although this process needs additional refinement, initial faculty reaction has been quite positive.

PROMOTION PROCESS

Each year at the end of the campus promotion and tenure cycle, the Chair has individual meetings with all potential promotion and tenure candidates inside the department. For untenured tenure-track faculty, the meeting is focused on the candidate’s timeline and generally includes a discussion of the mentor report for that year, the level of progress in the case, and specific actions to be taken in any areas that are deficient or worthy of specific attention. For tenured associate professors, the discussion is meant to determine the candidate’s progress toward promotion to full professor and the candidate’s interest in putting his or her case forward in the next P&T cycle.

Following these discussions, if there are any cases to be considered for the next cycle, the Chair tasks the candidate with generating a draft of their promotion package and convenes a meeting of the appropriate faculty (e.g. tenured full professors to consider promotion to full cases) to consider whether the case is at a level that merits further consideration. Once a set of promotion candidates has been determined, the chair appoints an individual department evaluation committee (DEC) for each candidate consisting of three faculty (two from within the department and one outside member) to prepare the case for formal consideration. The candidate then prepares a complete documentation package, and the DEC then prepares a report evaluating the candidate and making a positive or negative recommendation to the department. After the DEC report and the documentation are complete, this is made available to the appropriate group of faculty - the tenured faculty (in the case of promotion candidates to associate professor) or the professors (in the case of promotion candidates to Professor). The appropriate faculty meet to consider the case. The meeting opens with a straw vote (by secret ballot) which is tallied and announced to those present. This is followed by a detailed discussion of the case generally led by the DEC chair and ends with a final vote, also by secret ballot (the Chair tallies but does not participate in the voting). After the final vote, the Chair writes a report noting the outcome of the faculty vote and formulating his or her recommendation on the case. The full documentation package, the DEC report, and the Chair report are then forwarded to the campus-wide Faculty Promotion Council for consideration by the full school.

REVIEW PROCESS FOR STAFF

The University's Human Resources Office (HRO) oversees the review process of all university staff. HRO mandates that each staff member be given a written annual review along with a face-to-face meeting with his or her supervisor.

TEACHING EVALUATION

Teaching evaluation within the department is two-pronged. The primary source of information is the Student Opinion Form (SOF) which is administered campus wide by the Registrar. This instructor/course evaluation instrument incorporates a set of sixteen questions presented, as noted above, on a Likert scale, as well as an area for written commentary by the students. The SOF is administered electronically and must be submitted by the students to the Registrar prior to the release of course grades (a student's grade cannot be released until the SOF is submitted, so compliance is 100%). After the submission of course grades the numerical SOF data is summarized (max, min, average, and standard deviation) and distributed to the individual faculty and to their respective department chairs. The written comments are returned only to the individual faculty. In addition to the SOF, the Chair (and mentors in the case of junior faculty) will informally visit classes from time to time to aid in the assessment of teaching. The visits of mentors are generally recorded in the annual mentor reports so that they can be used in the faculty evaluation and promotion process.

COURSE EVALUATION AND REVIEW

As mentioned in the section on departmental operations, we have a standing course and curriculum committee to review and oversee our courses and curriculum, as well as coordinate our offerings with our various client curricula around the school. In addition, each course in the catalog has an official course coordinator who is charged with day-to-day monitoring of content, deciding on textbooks, handling course validation requests, etc.

OTHER ASSESSMENT

The chair currently conducts an exit briefing with each and every student receiving a degree in Applied Mathematics. This is done in a face-to-face meeting where the students are asked to give specific input on our graduate programs and their experience in them. Although the discussion is started using generic questions such as "What is your general impression of the program?" it also involves more specific questions like "What specific changes could we make that would improve the program?" The chair summarizes the responses and uses them as one tool for assessing the program.

BUDGET OVERVIEW

FACULTY LABOR BUDGET

First and foremost, it is critical to understand that NPS allocates department budgets in a manner very far removed from the models used in most universities. The process underwent a very large change in 2009 with the adoption of the "nine month model," but is still fundamentally one of 'steering by the wake' in that the current year's direct teaching (DT) budget allocation is primarily based on the number of eligible sections taught in the previous year (an eligible section is one in which there were 7 or more enrolled students). From our perspective the process of determining the DT budget is basically:

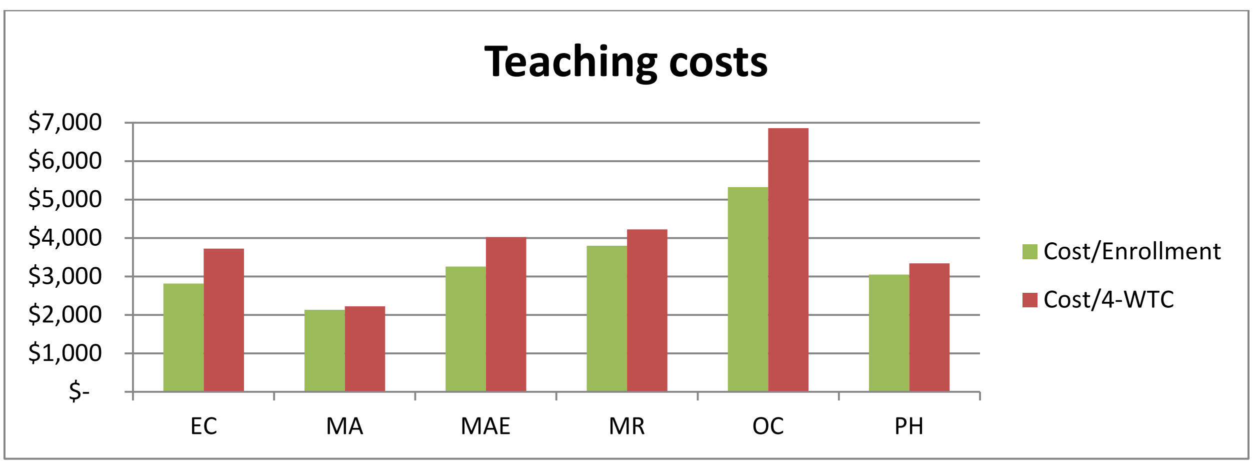
1. There is a base allocation that covers each tenure track faculty member for 9 months and the Chair for 12 months
2. Count the number of eligible sections (S) taught in the previous year
3. Determine the base capacity (C) of the department by multiplying the number of tenure-track faculty (not counting the Chair) by 4 (the nominal teaching load)
4. The exceptional sections E = S – C is divided by 8 and that many years of additional salary is added to the base budget

Because of the small enrollments, many required sections fall below the eligible threshold, and hence, even though they must be taught to meet requirements, they are not accounted for in the budget allocation. This generally leads to serious budget shortfalls in the summer quarter that are particularly difficult in the Department of Applied Mathematics, since this is one of our heaviest teaching quarters. The table below shows the history of initial faculty labor budget allocations versus actual end of year expenditures exclusive of extramural research funding. It is important to note two things. First, over the course of every year there are additional transfers for various reasons (e.g. one of our faculty teaches a class for another department). Second, the funding model underwent a fundamental change in 2009 that made it far more realistic, although there are still serious problems.

Year	Initial	Expended
2005	$1,581,875	$1,641,824
2006	$1,587,218	$2,064,705
2007	$1,365,424	$2,203,826
2008	$1,506,174	$2,778,515
2009	$2,423,897	$2,992,863

To expand on the current budget picture, we can analyze the situation in 2009 in more detail since this is the only year for which we have data under the new funding model. The initial allocation left out two important and known issues for the year – funding a full-year sabbatical for the previous chair and funding the work of one senior lecturer in managing an NPS program with Singapore. Even though both of these requirements were well understood by the academic planning office before the initial allocation, many hours had to be spent by the chair to get budget transfers to fund these external mandates, and, indeed, the full funding for these two issues did not arrive until August 21, 2009, just weeks before the close of the fiscal year. Had these properly been included in the initial allocation, we would have started the year with $2,673,897. Over the course of the year, there were additional transfers in and out for various reasons, and the department ended the year with a faculty labor shortfall of roughly $27,000. This shortfall is orders of magnitude less than in previous years where it was not uncommon to run nearly $1,000,000 in the red.

The most serious issue regarding faculty labor budgeting is the failure to properly fund essential teaching requirements that fall below the 7 student enrollment threshold. This introduces significant problems, as many required classes operate very near the threshold and enrollment variability basically leads to 'unfunded mandates' in that the department has to teach required core classes for which it has not been funded. What is more disturbing is the unwillingness of the administration to provide additional funding in light of the high degree of efficiency of our operations. Consider the following chart which shows the cost of resident teaching in six of the GSEAS departments (systems engineering is excluded because a high percentage of their teaching is distance learning and the budgeting process for that is very different). The chart shows two measures of cost. The first is computed by dividing the mission-funded teaching budget for each department by the total enrollments. The second is computed by dividing the mission-funded teaching budget for each department by the total number of four-unit weighted teaching credits (4-WTC). The four-unit weighted teaching credit is computed by dividing the weighted teaching credits by four. This measure is highly comparable to enrollments but compensates for some of the practices in other departments (e.g. splitting a 4-unit class into two 2-unit classes) that create the illusion of more teaching by proliferating sections.



It is very clear from the data that our costs are roughly half of those for the other GSEAS departments. Indeed, we are unquestionably the most efficient technical department at NPS. In light of this fact, it is difficult to understand the difficulty we have had trying to convince the administration to fund some of the smaller graduate-level sections we need to teach for our students and in order to maintain the professional competence of our faculty.

STAFF LABOR BUDGET

Staff labor budgets are such a continual problem that we simply operate with an expectation of running a deficit which will eventually be paid from campus funds. The department is authorized staff support of an Administrative Support Assistant and an Office Automation Assistant; this authorization provides barely sufficient staffing for a department of this size. The full cost of these positions is well-known in advance, but the initial allocation is consistently less than 60% of the known cost.

OPERATIONS

The department receives an annual operations (OPTAR) budget of roughly $40,000. This is used to pay virtually all operating costs, including office supplies, electronic equipment (printers, office computers, etc.), software licenses, department travel, honoraria, etc.

MAJOR GOALS FOR THE FUTURE

The department has made significant improvements since the last external review in 1985. It is worth noting that the 1985 self study notes seven issues from the previous review in 1979 and follows up with their status in 1985. Before proceeding it is worth revisiting those issues one more time. The first five issues have all been solved in the intervening years, they are:

The lack of a unified research effort is regarded as a weakness by members of the department – The 1985 report remarks that no progress had been made since 1979. Happily, in 2010 we have made great progress on this issue. The department has focused in a few key areas (applied analysis, scientific computation / numerical analysis, and discrete mathematics) and we have good collaborative efforts within the department as well as fruitful interdisciplinary collaborations.

Average to indifferent performance by faculty on loan from other departments – The 1985 report remarks that there had been progress as the department had been allowed to recruit faculty. It is a pleasure to note that this is no longer an issue, as we rarely use faculty from other departments to teach classes in mathematics. However, it bears mention that even in recent years, when we have used faculty from other departments, the quality of instruction has been consistently unacceptable. Moreover, there have been recent discussions of forcing the department to use faculty from other departments to teach calculus. This is a grave concern.

The department lacks expertise in applied algebra and discrete mathematical structures – This problem had been solved in 1985 and remains solved to this day as we have a very strong group of faculty in these areas.

The department has a need for increased expertise in numerical analysis, numerical methods for differential equations, and computation – The 1985 report notes that they had begun to address the problem, but had not yet done so. Happily, in 2010 this is no longer a problem. Indeed these areas are particular strengths for the department at the current time and, in fact, account for the majority of our external grant funding.

The department needs "new blood" – Although there is a history of long gaps in recruiting, it is not a major issue at the current time as we have recruited four new faculty in the last six years.

The remaining two issues are still very serious concerns:

Lack of graduate students in mathematics – The 1985 report notes that this was still a significant problem in 1985. Soon after that report, the 380 curriculum was reinstated and there followed a period of growth that showed real promise from 1990 to 2001, graduating an average of 6 students per year. By 2005 the closure of the 380 curriculum had brought the department back to 1985 levels, and we have struggled, with some success, to recover from there.

The lack of means to combat the teaching of mathematics courses in other departments – The 1985 report notes that this remains a problem and, sadly, the situation remains unchanged to this day. There is substantial course poaching and duplication across the campus, and repeated attempts to eliminate this needless duplication of effort have borne no fruit. This problem had been documented as early as 1947, and without intervention from the school administration, there is little hope that this practice will abate in the future.

These two issues are very closely related to the two very specific recommendations made in the external review from 1985. They are:

Encourage and support the growth of a mathematics degree program- The history here has been mixed. Indeed the school did reinstate the 380 curriculum following the 1985 review, and there was a solid period of support which led to the growth of a small but high quality program. Unfortunately, the ill-advised cancellation of the 380 curriculum in 2001 has done tremendous damage to the program from which we still have not recovered.

The Naval Postgraduate School should at least double its support for the teaching of advanced mathematics courses – It was specifically noted that the 15 units of graduate level math being offered in 1985 was far from sufficient. Since that time there has not been a significant increase in the support for teaching of advanced mathematics courses. Although the department has taught more than 30 units on numerous occasions, some of these sections have fewer than 7 students, and the department has to teach them "out of hide." In sum, this issue has not been addressed and remains a very serious one.

Having now reviewed past issues, we point out our main goals and issues moving forward. Many if not all of them are related to the issues from the last two reviews (1979 and 1985) as seen above. Indeed, all of them relate to the fact that the teaching profile in the department is excessively weighted toward classes at the 1000 and 2000 level; there are few opportunities to teach at the 4000 level. This issue was discussed above in the section on our instructional program where we noted a clear and critical contrast between our teaching profile and that in other comparable departments at NPS. The Department of Applied Mathematics is unique in that we do nearly 70% of our teaching at the first and second year undergraduate levels (1000 and 2000). This impacts faculty careers in several negative ways. First, the extremely limited graduate level teaching makes it far more difficult to develop and maintain active research programs. Second, the incredible demands of fast-paced remedial undergraduate level teaching makes classroom excellence a far more critical issue in promotion and tenure decisions than it is in other departments. Third, the time demands of teaching large sections of remedial mathematics to students just returning to university studies leaves little time to pursue research during teaching quarters. All of these issues are amplified by the widely varying levels of preparation of incoming students (including direct entry students who often come straight into multi-variable calculus without a refresher quarter in which to relearn basic single variable calculus).

There are three primary causes for this state of affairs –a lack of campus support for graduate level mathematics courses, a small graduate program, and course poaching -and we must address each of them in order to improve the situation.

GOAL #1 – REGULAR OFFERINGS OF GRADUATE LEVEL MATHEMATICS

We believe that a regular and reliable offering of graduate level mathematics would lead to increased enrollments in these very classes. There are increasing numbers of doctoral students in many technical curricula who would be eager to pursue a minor in mathematics, but often shy away from the option because they cannot be certain that classes they need for the minor will be offered. We have taken a first step with the creation of two certificate programs which attract both master's and Ph.D. students from other curricula. But even these are difficult to coordinate since we generally need to secure a full cohort (at least seven students) before we begin. If, on the other hand, students and program officers knew in advance that certain classes would be offered on a regular basis (annually or biannually), then we believe we could fill the seats with students seeking certificates, as well as those Ph.D. students in need of a minor. An administration commitment to fund just twelve sections per year at the 4000 level would likely be enough to put us on a path to self-sufficiency.

GOAL #2 – EXPAND THE GRADUATE PROGRAM

The Department of Applied Mathematics is currently the only department without a Navy-sponsored master's degree program. While we have been able to rebuild a steady, although small, input of students from the Army and complement this with a few dual master's, the numbers are simply not sufficient to maintain a high-quality graduate level department. Although faculty are generally engaged in thesis advising both inside and outside the department, a larger group of math graduate students would materially improve our opportunities to teach graduate level mathematics as well as maintain active and relevant research programs. We need to convince the Navy to officially reinstate the 380 curriculum and to begin sending students. We believe there is a real need for a core group of officers with graduate math degrees to teach at the US Naval Academy. Moreover, we believe the Navy would benefit by having more members of the officer corps with advanced degrees in mathematics.

GOAL #3 – REDUCE COURSE POACHING AND DUPLICATION

There is a significant and ongoing problem with course poaching and duplication by other departments. This was clearly noted in the 1985 review and continues to this day. It is worth special mention that this is a long-standing problem at NPS. Indeed, in 1947 the Heald Report (*Report on the Educational Program of the United States Naval Postgraduate School. By an Advisory Committee to the American Council on Education, Henry T. Heald, Chairman. New York: American Council on Education, June 27, 1947*) made special mention of this problem. The report noted that the school's failure to use standard individual courses as building blocks resulted in a "complicated array" of very similar courses. And furthermore, that this led to small, uneconomical classes and related inefficiencies. This practice continues to have a serious negative impact both on the department and the school in several ways.

Above all, it is an inefficient use of school resources since this practice results in multiple versions of essentially the same material being taught in very small sections by a variety of people in a variety of departments. This practice is particularly prevalent within GSEAS where, for example, nearly half of the departments offer their own course in ocean acoustics, and nearly every department offers its own version of a numerical methods course. This practice also hurts the students since they are often taking classes that have been watered down or lack academic rigor precisely because they are being taught outside of the department in which they should be legitimately housed.

More troubling for us is the fact that most of the poaching and duplication occurs at the 3000 and 4000 level, so it is a major contributor to the unhealthy teaching profile in the department. For example, consider PH3991 – Theoretical Physics. The textbook for this course is *Mathematical Methods in the Physical Sciences* by Mary Boas, and the course is essentially one on methods of applied mathematics. This class is generally offered twice a year with a dozen or more students each time. There are many more examples similar to this one all over campus. For a detailed description of course poaching and duplication issues currently affecting the department see Appendix E.

APPENDICES

APPENDIX A: FACULTY PROFILES

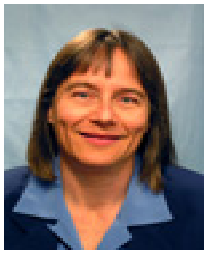
Carlos Borges (vita): **Professor and Department Chair, PhD. UC Davis** (Home Page)

Research Interests: Numerical Analysis, Numerical Linear Algebra, Applied Approximation Theory, Orthogonal Polynomials, Floating-point Computation.

David Canright (vita): **Associate Professor and Associate Chair for Computing , PhD. UC Berkeley** (Home Page)

Research Interests: Fluid Dynamics, Materials Processing, Cryptography, Orbital Mechanics, Acoustics, Fractal Geometry.

Les Carr (vita): **Lecturer, PhD. Naval Postgraduate School**



Margaret Cheney (vita) : **Research Professor, Ph.D. Indiana University** (Home Page)

Research Interests: Inverse Problems in Acoustics and Electromagnetics, Particularly Radar Imaging

Don Danielson (vita): **Professor, PhD. Harvard University** (Home Page)

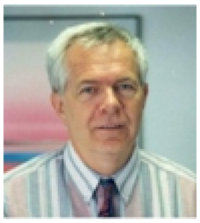
Research Interests: Use Theory and Software to Model Dynamics of Fluids and Structures, Improve Analytical and Numerical Techniques for Prediction of Satellite Orbits.

Doyle Daughtry (vita): **Lecturer, MA. East Carolina University**

Research Interests: Mathematical Education.

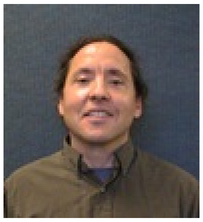
Fariba Fahroo (vita): **Professor, PhD. Brown University**

Research Interests: Optimal Control Theory, Numerical Optimal Control Theory, Control of Distributed Parameter Systems, Numerical Analysis.



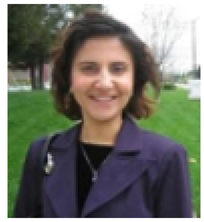
Hal Fredricksen (vita): **Professor, PhD. University of Southern California** (Home Page)

Research Interests: Application of Combinatorial Techniques and the Results to Problems of Digital Communications, Cryptography and Computer Security, Coding and Information Theory.



Chris Frenzen (vita): **Associate Professor, PhD. University of Washington** (Home Page)

Research Interests: Asymptotic Analysis, Dynamical Systems, Applied Mathematics.

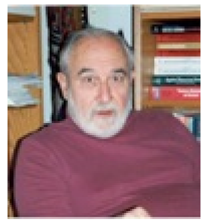


Ralucca Gera (vita): **Assistant Professor, PhD. Western Michigan University** (Home Page)

Research Interests: Graph Theory, Combinatorial Applications, Artificial Intelligence.

Frank Giraldo (vita): **Professor and Associate Chair for Research, PhD. University of Virginia** (Home Page)

Research Interests: Spectral Elements and Discontinuous Galerkin Methods, Domain Decomposition Methods and Parallel computing, Time-Integrators, Adaptive Methods.



Bill Gragg (vita): **Professor, PhD. UCLA** (Home Page)

Research Interests: Computational Complex Analysis, Numerical Linear Algebra.

Wei Kang (vita): **Professor, PhD. UC Davis** (Home Page)

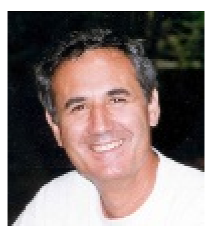
Research Interests: Nonlinear Control Theory with Engineering Applications, including Bifurcation Control, Normal Forms and Invariants, H-infinity Control, Formation Control and their Applications in the Control of Aircraft.

Arthur J. Krener (vita): **Distinguished Visiting Professor, PhD. UC Berkeley** (Home Page)

Research Interests: Control and Estimation.

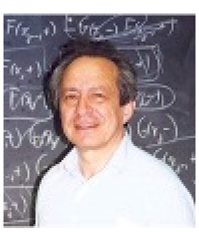
Bard Mansager (vita): **Senior Lecturer and Associate Chair for Instruction, MA. UC San Diego**

Research Interests: Combat Modeling.



Beny Neta (vita): **Professor, PhD. Carnegie-Mellon University** (Home Page)

Research Interests: Finite Elements, Orbit Predictions, Parallel Computing.



Guillermo Owen (vita): **Distinguished Professor, PhD. Princeton University**

Research Interests: Game Theory, Terrorism and Low-intensity Conflict, Voting, Economic Equilibrium.

Craig Rasmussen (vita): **Associate Professor, PhD. University of Colorado** (Home Page)

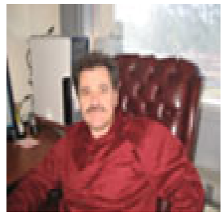
Research Interests: Graph Theory, Network Design and Optimization, Heuristic Algorithms in Combinatorial Optimization.

Clyde Scandrett (vita): **Professor, PhD. Northwestern University**

Research Interests: Active Materials, and the Coupling between Elastic, Fluid, and Piezoelectric Media, Wave Propagation Phenomenon, Electromagnetic Wave Propagation, the Biot Theory of Wave Propagation in Porous Media.

Hong Zhou (vita): **Associate Professor, PhD. UC Berkeley** (Home Page)

Research Interests: Scientific Computation, Mathematical Modeling of Nonlinear Phenomena, Structure and Flow Properties of Complex Polymeric and Nano-Composite Fluids.



Pantelimon Stanica (vita): **Professor, PhD. SUNY Buffalo** (Home Page)

Research Interests: Cryptography & Coding theory, Boolean Functions, Logic and Discrete Mathematics, Number Theory, Graph Theory, Combinatorial Mathematics, Algebra.

APPENDIX B: FACULTY AWARDS AND HONORS

CAMPUS-WIDE AWARDS

The Menneken Faculty Award for Excellence in Scientific Research:

- Frank Giraldo
- Wei Kang

The Sigma Xi Carl E. Menneken Research Award:

- Bill Gragg

The Rear Admiral John Jay Schieffelin Award for Excellence in Teaching:

- Carlos Borges
- Gordon Latta (Emeritus)
- Bard Mansager
- Arthur Schoenstadt (Emeritus)
- Maurice Weir (Emeritus)
- Carroll Wilde (Emeritus)

FELLOWS

AIAA Fellows:

- Fariba Fahroo (Associate Fellow)
- Beny Neta (Associate Fellow)

ICA Fellows:

- Ralucca Gera (Associate Fellow)
- Craig Rasmussen
- Pante Stanica (Associate Fellow)

IEEE Fellows:

- Wei Kang
- Art Krener

SIAM Fellows:

- Art Krener

OTHER AWARDS AND DISTINCTIONS

Guillermo Owen holds the title of Distinguished Professor and is a member of the following:

- Colombian Academy of Exact and Physical Sciences
- Royal Academy of Sciences and Arts of Catalonia
- Third World Academy of Sciences

APPENDIX C: PEER REVIEWED FACULTY PUBLICATIONS – 2005 TO 2009

2009

Bedrossian, N., Bhatt, S., Kang, W. & Ross, I.M. 2009, "Zero-propellant maneuver guidance", *IEEE Control Systems Magazine,* vol. 29, no. 5, pp. 53-73.

Borges, C.F. 2009, "A full-Newton approach to separable nonlinear least squares problems and its application to discrete least squares rational approximation", *Electronic Transactions on Numerical Analysis,* vol. 35, pp. 57-68.

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Chartrand, G., Okamoto, F., Rasmussen, C.W. & Zhang, P. 2009, "The set chromatic number of a graph", *Discussiones Mathematicae Graph Theory,* vol. 29, pp. 545-561.

Chun, C., Bae, H.J. & Neta, B. 2009, "New families of nonlinear third-order solvers for finding multiple roots", *Computers & Mathematics with Applications,* vol. 57, no. 9, pp. 1574-1582.

Chun, C. & Neta, B. 2009, "A third-order modification of Newton's method for multiple roots", *Applied Mathematics and Computation,* vol. 211, no. 2, pp. 474-479.

Chun, C. & Neta, B. 2009, "Certain improvements of Newton's method with fourth-order convergence", *Applied Mathematics and Computation,* vol. 215, pp. 821-828.

Cusick, T.W., Li, Y. & Stanica, P. 2009, "On a conjecture of balanced symmetric Boolean functions", *J. Mathematical Cryptology,* vol. 3, no. 4, pp. 273--290.

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Cusick, T.W. & Stanica, P. 2009, "Sums of the Thue-Morse sequence over arithmetic progressions", *Advances and Applications in Discrete Mathematics,* vol. 4, no. 2, pp. 127-135.

Dartyge, C., Luca, F. & Stanica, P. 2009, "On digit sums of multiples of an integer", *J. Number Theory.,* vol. 129, no. 11, pp. 2820-2830.

Dea, J.R., Giraldo, F.X. & Neta, B. 2009, "High-order non-reflecting boundary conditions for the linearized 2-D Euler equations: No mean flow case", *Wave Motion,* vol. 46, no. 3, pp. 210-220.

Gera, R., Hattingh, J.H., Jafari Rad, N., Joubert, E.J. & van der Merwe, L. 2009, "Vertex and edge critical total restrained domination in graphs", *The Bulletin of the Institute of Combinatorics and its Applications,* vol. 57, pp. 107-117.

Haegel, N.M., Mills, T.J., Talmadge, M., Scandrett, C.L., Frenzen, C.L., Yoon, H., Fetzer, C.M. & King, R.R. 2009, "Direct imaging of anisotropic minority-carrier diffusion in ordered GaInP", *Journal of Applied Physics,* , pp. 023711 (5 pp.).

Jangveladze, T., Kiguradze, Z. & Neta, B. 2009, "Large time behavior of solutions to a nonlinear integro-differential system", *Journal of Mathematical Analysis and Applications,* vol. 351, no. 1, pp. 382-391.

Jangveladze, T., Kiguradze, Z. & Neta, B. 2009, "Large time behavior of solutions and finite difference scheme to a nonlinear integro-differential equation", *Computers & Mathematics with Applications,* vol. 57, no. 5, pp. 799-811.

Jangveladze, T., Kiguradze, Z. & Neta, B. 2009, "Finite difference approximation of a nonlinear integro-differential system", *Applied Mathematics and Computation,* vol. 215, pp. 615-628.

Kang, W., Ross, I.M., Pham, K. & Gong, Q. 2009, "Autonomous observability of networked multi-satellite systems", *AIAA J. of Guidance, Control, & Dynamics,* vol. 32, no. 3, pp. 869-877.

Kilic, E. & Stanica, P. 2009, "Generating matrices for weighted sums of second order linear recurrences", *J. Integer Seq.,* vol. 12, no. 2, pp. Article 09.2.7, 11.

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McCormick, G.H. & Owen, G. 2009, "Terrorists and their sponsors: An inquiry into trust and double-crossing" in *Mathematical Methods in Counterterrorism*, ed. J. Farley,.

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Eroh, L. & Gera, R. 2008, "Global alliance partition in trees", *Journal of Combinatorial Mathematics and Combinatorial Computing,* , no. 66, pp. 161-9.

Fahroo, F. & Ross, I.M. 2008, "Pseudospectral methods for infinite-horizon optimal control problems", *Journal of Guidance Control and Dynamics,* vol. 31, no. 4, pp. 927-936.

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APPENDIX D: DISSERTATIONS AND THESES – 2005 TO 2009

DISSERTATIONS FROM 2005 TO 2009

Dea, J.R. (2008), *High-order non-reflecting boundary conditions for the linearized Euler equations [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Phillips, D.D. (2008), *Mathematical modeling and optimal control of battlefield information flow [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

MASTER'S THESES BY YEAR

2009

Alevras, D., *Simulating tsunamis in the Indian Ocean with real bathymetry by using a high-order triangular discontinuous Galerkin oceanic shallow water model [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Bernotavicius, C.S., *Modeling a 400 Hz signal transmission through the South China Sea basin [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Geary, A.C., *Analysis of a man-in-the-middle attack on the Diffie-Hellman key exchange protocol [electronic resource]*, Naval Postgraduate School, Monterey, California.

Gibbons, S.L., *Impacts of sigma coordinates on the Euler and Navier-Stokes equations using continuous Galerkin methods [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Kim, A.M., *Simulating full-waveform LIDAR [electronic resource]*, Naval Postgraduate School, Monterey, California.

Mantzouris, P., *Computational algebraic attacks on the Advanced Encryption Standard (AES) [electronic resource]*, Naval Postgraduate School, Monterey, California.

McNabb, M.E., *Optimizing the router configurations within a nominal Air Force base [electronic resource]*, Naval Postgraduate School, Monterey, California.

Petrakos, N., *Cube-type algebraic attacks on wireless encryption protocols [electronic resource]*, Naval Postgraduate School, Monterey, California.

Smith, W.T., *A game theoretic approach to convoy routing [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

2008

Damalas, K.A., *Analysis of analytic models for the effect of Insurgency*, Naval Postgraduate School, Monterey, Calif.

Fernandez, C.K., *Pascal polynomials over GF(2) [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Florkowski, S.F., *Spectral graph theory of the Hypercube [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Giannoulis, G., *Efficient implementation of filtering and resampling operations on Field Programmable Gate Arrays (FPGAs) for Software Defined Radio (SDR) [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Pollatos, S., *Solving the maximum clique problems on a class of network graphs, with applications to social networks [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Shankar, A., *Optimal jammer placement to interdict wireless network services [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

2007

De Luca, T.J., *Performance of Hybrid Eulerian-Lagrangian Semi-Implicit time integrators for nonhydrostatic mesoscale atmospheric modeling [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Fletcher, D.M., *Realizable triples in dominator colorings [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Karczewski, N.J., *Optimal aircraft routing in a constrained path-dependent environment [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Martinsen, T., *Refinement composition using doubly labeled transition graphs [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Spence, L.J., *On the calculation of particle trajectories from sea surface current measurements and their use in satellite sea surface products off the Central California Coast [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

Wilson, L.M.Z., *Controllability of Non-Newtonian fluids under homogeneous flows [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

2006

Sopko, J.J., *Modeling fluid flow by exploring different flow geometries and effect of weak compressibility [electronic resource]*, Naval Postgraduate School; Available from National Technical Information Service, Monterey, Calif; Springfield, Va.

2005

House, J.B. , *Optimizing the Army's base realignment and closure implementation while transforming and at war [electronic resource]*, Naval Postgraduate School, Monterey, Calif.

APPENDIX E: COURSE POACHING AND DUPLICATION

Course poaching and duplication are serious issues at NPS. The problem is longstanding and was noted as early as 1947 in the Heald Report (*Report on the Educational Program of the United States Naval Postgraduate School. By an Advisory Committee to the American Council on Education, Henry T. Heald, Chairman. New York: American Council on Education, June 27, 1947*). The report noted that the school's failure to use standard individual courses as building blocks resulted in a "complicated array" of very similar courses. And furthermore, that this led to small, uneconomical classes and related inefficiencies. This practice continues to have a serious negative impact both on the department and the school.

We now outline the most serious issues of poaching and duplication currently plaguing the department.

MATHEMATICAL METHODS

PH3991 THEORETICAL PHYSICS *(4-1) SPRING/FALL*
DISCUSSION OF HEAT FLOW, ELECTROMAGNETIC WAVES, ELASTIC WAVES, AND QUANTUM-MECHANICAL WAVES; APPLICATIONS OF ORTHOGONAL FUNCTIONS TO ELECTROMAGNETIC MULTIPOLES, ANGULAR MOMENTUM IN QUANTUM MECHANICS, AND TO NORMAL MODES ON ACOUSTIC AND ELECTROMAGNETIC SYSTEMS. APPLICATIONS OF COMPLEX ANALYSIS TO GREEN FUNCTION IN QUANTUM MECHANICS AND ELECTROMAGNETISM. APPLICATION OF FOURIER SERIES AND TRANSFORMS TO RESONANT SYSTEMS. APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATION TECHNIQUES TO EQUATION OF PHYSICS. PREREQUISITES: BASIC PHYSICS, MULTIVARIABLE CALCULUS, VECTOR ANALYSIS, FOURIER SERIES, COMPLEX NUMBERS, AND ORDINARY DIFFERENTIAL EQUATIONS.

Comments: This is essentially a mathematics class and is taught using a mathematics textbook "*Mathematical Methods in the Physical Sciences*" by Mary L. Boas. We do not currently teach a version of this class but this is a prime example of course poaching. The fact that this 3000 level class has been poached means that the math department has fewer opportunities to teach at that level. PH3991 is offered twice per year (every spring and fall) to about 15 students each time.

BUSINESS CALCULUS

MN2039 BASIC QUANTITATIVE METHODS IN MANAGEMENT (4-0) FALL/SPRING
THIS COURSE INTRODUCES THE MATHEMATICAL BASIS REQUIRED FOR ADVANCED MANAGEMENT AND COST-BENEFIT ANALYSIS. MATH TOPICS INCLUDE ALGEBRA, GRAPHS, DIFFERENTIAL CALCULUS, INCLUDING BOTH SINGLE AND MULTIPLE VARIABLE FUNCTIONS, AND INDEFINITE AND DEFINITE INTEGRALS. MANAGEMENT CONCEPTS INCLUDE COST-BENEFIT AND COST-EFFECTIVENESS ANALYSIS, MARGINAL ANALYSIS, UNCONSTRAINED AND CONSTRAINED OPTIMIZATION, AND WELFARE ANALYSIS. PREREQUISITE: COLLEGE ALGEBRA OR CONSENT OF INSTRUCTOR.

Comments: This class is a direct duplication of:

MA2300 MATHEMATICS FOR MANAGEMENT (5-0) WINTER/SPRING/SUMMER
MATHEMATICAL BASIS FOR MODERN MANAGERIAL TOOLS AND TECHNIQUES. ELEMENTS OF FUNCTIONS AND ALGEBRA; DIFFERENTIAL CALCULUS OF SINGLE- AND MULTI-VARIABLE FUNCTIONS; INTEGRATION (ANTIDIFFERENTIATION) OF SINGLE-VARIABLE FUNCTIONS. APPLICATIONS OF THE DERIVATIVE TO RATES OF CHANGE, CURVE SKETCHING, AND OPTIMIZATION, INCLUDING THE METHOD OF LAGRANGE MULTIPLIERS. PREREQUISITE: COLLEGE ALGEBRA.

It uses the same textbook (Brief Calculus and Its Applications – Goldstein, Lay, and Schneider) and the syllabus was adapted from the syllabus for MA2300. The students who used to take MA2300 now take MN2039 instead (MA2300 has not been taught since 2001 as a result of this outright theft of a class). MN2039 is offered once per year (every fall) to about 30 students.

NUMERICAL METHODS

ME3440 ENGINEERING ANALYSIS (4-0) AS REQUIRED
RIGOROUS FORMULATION OF ENGINEERING PROBLEMS ARISING IN A VARIETY OF DISCIPLINES. APPROXIMATE METHODS OF SOLUTION. FINITE DIFFERENCE METHODS. INTRODUCTION TO FINITE ELEMENT METHODS. PREREQUISITES: ME2201, ME2502 OR ME2503, AND ME3611.

ME3450 COMPUTATIONAL METHODS IN MECHANICAL ENGINEERING (3-2) FALL/SPRING
THE COURSE INTRODUCES STUDENTS TO THE BASIC METHODS OF NUMERICAL MODELING FOR TYPICAL PHYSICAL PROBLEMS ENCOUNTERED IN SOLID MECHANICS AND THE THERMAL/FLUID SCIENCES. PROBLEMS THAT CAN BE SOLVED ANALYTICALLY WILL BE CHOSEN INITIALLY AND SOLUTIONS WILL BE OBTAINED BY APPROPRIATE DISCRETE METHODS. BASIC CONCEPTS IN NUMERICAL METHODS, SUCH AS CONVERGENCE, STABILITY AND ACCURACY, WILL BE INTRODUCED. VARIOUS COMPUTATIONAL TOOLS WILL THEN BE APPLIED TO MORE COMPLEX PROBLEMS, WITH EMPHASIS ON FINITE ELEMENT AND FINITE DIFFERENCE METHODS, FINITE VOLUME TECHNIQUES, BOUNDARY ELEMENT METHODS AND GRIDLESS LAGRANGIAN METHODS. METHODS OF MODELING CONVECTIVE NON-LINEARITIES, SUCH AS UPWIND DIFFERENCING AND THE SIMPLER METHOD, WILL BE INTRODUCED. DISCUSSION AND STRUCTURAL MECHANICS, INTERNAL AND EXTERNAL FLUID FLOWS, AND CONDUCTION AND CONVECTION HEAT TRANSFER. STEADY STATE, TRANSIENT AND EIGENVALUE PROBLEMS WILL BE ADDRESSED. PREREQUISITES: ME3150, ME3201, ME3611.

MR4323 NUMERICAL AIR AND OCEAN MODELING (4-2) SPRING/FALL
NUMERICAL MODELS OF ATMOSPHERIC AND OCEANIC PHENOMENA. FINITE DIFFERENCE TECHNIQUES FOR SOLVING HYPERBOLIC, PARABOLIC AND ELLIPTIC EQUATIONS, LINEAR AND NONLINEAR COMPUTATIONAL INSTABILITY. SPECTRAL AND FINITE ELEMENT MODELS. FILTERED AND PRIMITIVE EQUATION PREDICTION MODELS. SIGMA COORDINATES. OBJECTIVE ANALYSIS AND INITIALIZATION. MOISTURE AND HEATING AS TIME PERMITS. PREREQUISITES: MR4322, OC4211, PARTIAL DIFFERENTIAL EQUATION, MA3232 DESIRABLE.

OC4323 NUMERICAL AIR AND OCEAN MODELING (4-2) AS REQUIRED
NUMERICAL MODELS OF ATMOSPHERIC AND OCEANIC PHENOMENA. FINITE DIFFERENCE TECHNIQUES FOR SOLVING ELLIPTIC AND HYPERBOLIC EQUATIONS, LINEAR AND NON-LINEAR COMPUTATIONAL INSTABILITY. SPECTRAL AND FINITE ELEMENT MODELS. FILTERED AND

PRIMITIVE EQUATION PREDICTION MODELS. SIGMA COORDINATES. OBJECTIVE ANALYSIS AND INITIALIZATION. MOISTURE AND HEATING AS TIME PERMITS. PREREQUISITES: MR4322 OR OC4211, PARTIAL DIFFERENTIAL EQUATIONS; NUMERICAL ANALYSIS DESIRABLE.

PC2911 INTRODUCTION TO COMPUTATIONAL PHYSICS (3-2) AS REQUIRED
AN INTRODUCTION TO THE ROLE OF COMPUTATION IN PHYSICS, WITH EMPHASIS ON THE PROGRAMMING OF CURRENT NONLINEAR PHYSICS PROBLEMS. ASSUMES NO PRIOR PROGRAMMING EXPERIENCE. INCLUDES A TUTORIAL ON THE C PROGRAMMING LANGUAGE AND MATLAB, AS WELL AS AN INTRODUCTION TO NUMERICAL INTEGRATION METHODS. COMPUTER GRAPHICS ARE USED TO PRESENT THE RESULTS OF PHYSICS SIMULATIONS. PREREQUISITES: NONE.

SE3030 QUANTITATIVE METHODS OF SYSTEMS ENGINEERING (3-2)
THIS COURSE DISCUSSES ADVANCED MATHEMATICAL AND COMPUTATIONAL TECHNIQUES THAT FIND COMMON APPLICATION IN SYSTEMS ENGINEERING. IT ALSO PROVIDES AN INTRODUCTION TO MATLAB, A COMPUTATIONAL TOOL USEFUL IN OBTAINING QUANTITATIVE ANSWERS TO ENGINEERING PROBLEMS. AMONG THE TOPICS ADDRESSED IN THIS COURSE ARE VECTOR ANALYSIS, COMPLEX ANALYSIS, INTEGRAL TRANSFORMS, SPECIAL FUNCTIONS, NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS, AND NUMERICAL ANALYSIS. PREREQUISITES: SE1002, SE3100 OR CONSENT OF INSTRUCTOR.

Comments:

This collection of classes all duplicate material from

> **MA3232 NUMERICAL ANALYSIS** (4-0) SPRING/SUMMER/FALL/WINTER
> PROVIDES THE BASIC NUMERICAL TOOLS FOR UNDERSTANDING MORE ADVANCED NUMERICAL METHODS. TOPICS FOR THE COURSE INCLUDE: SOURCES AND ANALYSIS OF COMPUTATIONAL ERROR, SOLUTION OF NONLINEAR EQUATIONS, INTERPOLATION AND OTHER TECHNIQUES FOR APPROXIMATING FUNCTIONS, NUMERICAL INTEGRATION AND DIFFERENTIATION, NUMERICAL SOLUTION OF INITIAL AND BOUNDARY VALUE PROBLEMS IN ORDINARY DIFFERENTIAL EQUATIONS, AND INFLUENCES OF HARDWARE AND SOFTWARE. PREREQUISITES: MA1115, MA2121 AND ABILITY TO PROGRAM IN MATLAB AND MAPLE.
>
> **MA3243 NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS** (4-1) WINTER
> COURSE DESIGNED TO FAMILIARIZE THE STUDENT WITH ANALYTICAL TECHNIQUES AS WELL AS CLASSICAL FINITE DIFFERENCE TECHNIQUES IN THE NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS. IN ADDITION TO LEARNING APPLICABLE ALGORITHMS, THE STUDENT WILL BE REQUIRED TO DO PROGRAMMING. TOPICS COVERED INCLUDE: IMPLICIT, EXPLICIT, AND SEMI-IMPLICIT METHODS IN THE SOLUTION OF ELLIPTIC AND PARABOLIC PDE'S, ITERATIVE METHODS FOR SOLVING ELLIPTIC PDES (SOR, GAUSS-SEIDEL, JACOBI), THE LAX-WENDROFF AND EXPLICIT METHODS IN THE SOLUTION OF 1ST AND 2ND ORDER HYPERBOLIC PDES. PREREQUISITES: MA3132 AND THE ABILITY TO PROGRAM IN A HIGH LEVEL LANGUAGE SUCH AS FORTRAN, C, OR MATLAB.

Several of the classes, particularly MR4323 and OC4323, appear to be poor alternatives to a proper class in numerical analysis such as MA3232 or MA3243. Some of the classes are taught regularly and others are not. In particular:

- ME3440 has not been taught since 1998.

- ME3450 is taught every fall and spring to about a dozen students.
- MR4323 is taught every year in the spring to roughly 8-10 students.
- OC4323 is taught every year in the fall usually to fewer than 6 students.
- PC2911 is taught sporadically, roughly once a year in either winter or summer with about a dozen students.
- SE3030 appears to never have been taught.

APPENDIX F: SELF STUDY 1985

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APPENDIX G: PROGRAM REVIEW 1985

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APPENDIX H: DEPARTMENTAL STRATEGIC PLAN

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APPENDIX I: LIBRARY SUPPORT

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